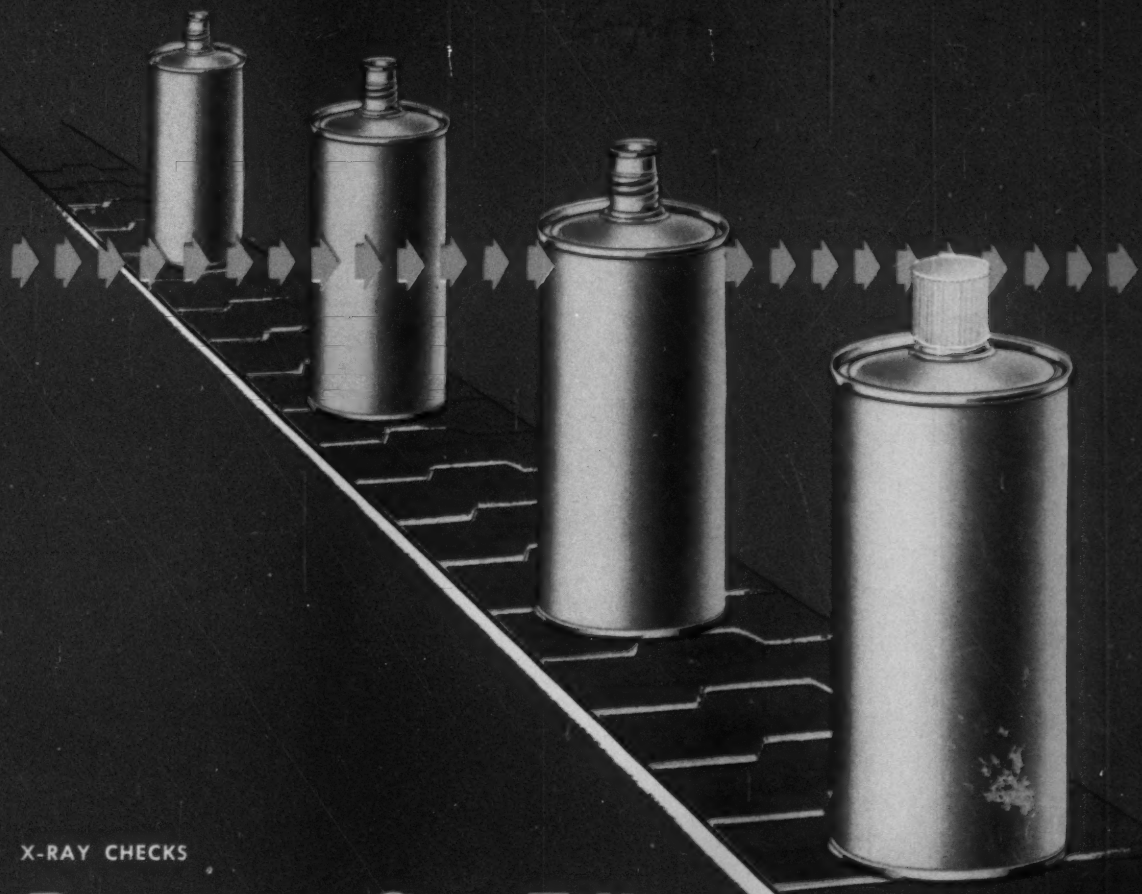
AUTOMATION

FEBRUARY 1956



X-RAY CHECKS

Detergent Can Filling

The Magazine of Automatic Operations

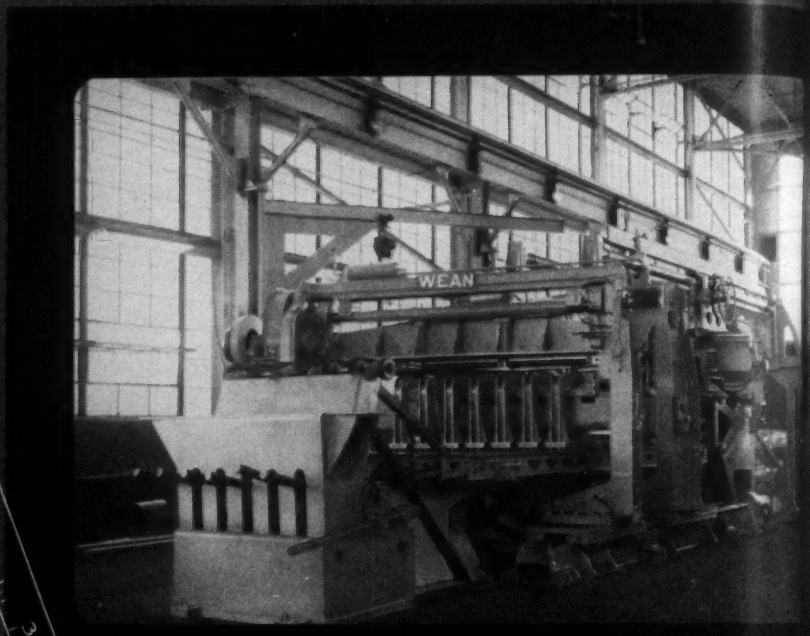
- Developing a Maintenance Program
- How Numerical Control Works
- Electronics in Process Control
- Projectiles Welded Automatically

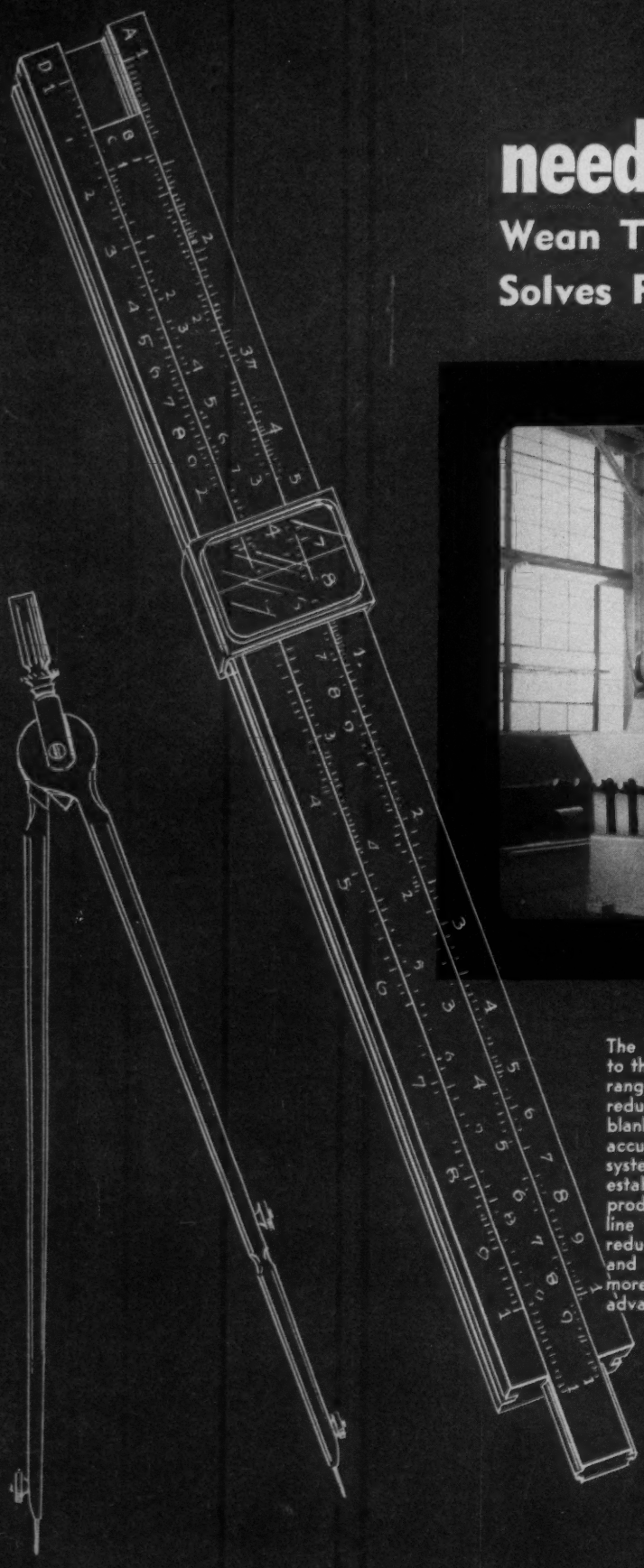
CONTENTS — PAGE 3

A PENTON PUBLICATION

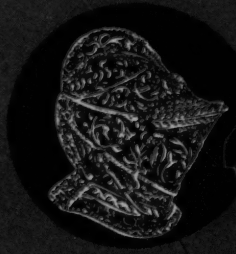
need an idea?

Wean Trapezoidal Shear Line Solves Problem for Auto Maker





The Wean Trapezoidal Shear Line was developed as an answer to the high speed blanking of irregularly shaped pieces in the broa range that can be described as trapezoids or parallelograms. Th reduces tremendously the cost of expensive die setup in major blanking presses. Two pieces are made at each index with the accuracy that can only be achieved by a measured length indexi system. The cut can range from 45° to 90° angles. The latter w establishes the line as a straight cut-up unit with twice the norm production of conventional shear lines. At Wean, we consider line as another important step forward in our policy of cost reduction through progressive engineering. People in the automot and metal fabricating fields have come to look more and more toward Wean Equipment for spectacular advances in machinery for metal processing.



Wean

EQUIPMENT CORPORATION
CLEVELAND, OHIO

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FEBRUARY, 1956
Vol. 3—No. 2

AUTOMATION ®

THE MAGAZINE OF AUTOMATIC OPERATIONS

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REGULAR DEPARTMENTS

Automation Outlook, 4
Automation News, 7
Detroit Dateline, 23
New Equipment, 79
New Components, 98
New Literature, 112
Reader's Reply Card, 115
Abstracts, 118
Key to Air Force Logistics
Patents, 126
Editorial Index, 128
New Books, 130

Progress and Obsolescence, 27
EDITORIAL—automation should be viewed in the light of progress and advanced design, not obsolescence.

Developing a Maintenance Program, 28
NAPOLEON PERKOWSKI—industrial engineering techniques used in production can aid in controlling maintenance.

Automatic Plating of Bumpers, 34
AUTOMATION TODAY—giant-sized installation provides for automatic movement of parts into and out of tanks.

A Caveat on Computers, 38
E. W. LEAVER and J. J. BROWN—evolution of computer control in automation will be along practical lines.

V-Belts in the Conveyor Family, 42
NEW APPLICATIONS—power transmission element used as materials handling element to move workpieces.

Inspecting and Testing Magnets, 44
AUTOMATIC EQUIPMENT—dimensional sizes and magnetic properties automatically checked by machines.

How Numerical Control Works, 45
ROBERT W. BROOKS—*and, or* and *not* connectives of binary representations are utilized in computers.

Use Resistance Potentiometers, 52
HOLLIS L. GRAY, JR.—devices that convert physical quantities to electrical response are required in automation.

Newsprint from Hardwoods, 58
G. W. GASSETT—research and automation provide new process to increase utilization of natural resources.

Detergent Production Line, 63
IRA MENDLESON—X-ray inspecting equipment checks height of fill in cans on moving conveyor.

Electronics in Process Control, 67
ROBERT A. DUNCAN—considerations that led to choice of electronics for control system on a catalytic oil reformer.

Projectiles Welded Automatically, 72
V. N. HANSFORD—design for automation involves both the product in question and the production process.

automation outlook

NO FEARS

". . . I would like to talk a little bit about automation because I think I would like to try to put it in the concept that I see it, which doesn't have any of these fears, any of these future unknowns. Based on what we have researched in the Labor Department, we see in the next ten years an acceleration of worker productivity brought about by increased technological change and that is what automation is . . ."—*James P. Mitchell, Secretary of Labor.*

MAINTENANCE OPPORTUNITY

". . . with an increasing use of automated equipment, it is apparent that future opportunities for cost reduction will exist in the sphere of maintenance rather than production. This fact, coupled with the importance of continuous operation of the automated equipment, points out the ultimate need of applying industrial engineering techniques to maintenance operations if the function is to be successfully controlled . . ."—*Napoleon Perkowski, industrial engineering department, University of Southern California.* *See Page 33.*

DOWN TO EARTH

". . . man, even with all his adaptability and marvelous sensitivity to outside impressions, has been found wanting when it comes to operating today's highly complex industrial processes. And because men simply aren't up to the job, the trend in the last few years has been to introduce more automatic equipment. This is a sound move and one which will lead in time to higher levels of productivity and better design. There is, however, an urgent need for a critical appraisal of the role of the automatic computer in achieving these desirable goals in view of some of the unique theories and misconceptions regarding "giant brains" which have become so popular . . ."—*E. W. Leaver, president, Electronic Associates Ltd., and J. J. Brown, staff member, Aluminum Limited Group Co.* *See Page 38.*

CONTROLLED MANUFACTURE AND MEASUREMENT

". . . in terms of its peacetime role, the machine tool industry's opportunity and duty are plain. It is to transfer our manufacturing processes from labor's back to the machine itself. Every year that passes sees a permanent contribution and advance toward this end. The combination of controlled manufacture and measurement make the economies of automated production and assembly possible. In turn, this makes possible both increasing productivity and a more abundant life for all people . . ." —*Louis Polk, chairman and president, the Sheffield Corp.*

REVISE OUR ACCOUNTING

". . . instead of using the old standard of man-hours per piece, we should revise our accounting system to evaluate costs on a basis of machine-hours per piece. This would enable us to reduce general overhead costs as they are currently known, and to classify production costs into direct material, direct labor, direct machine and direct variable overheads. Perhaps in time, the direct labor cost will disappear . . ."—*B. W. Saunders, associate professor, Cornell University.*

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BPA

AUTOMATION news

Today's events and developments in the field of automation

Mechanized Camera Speeds List Preparation

NEW mechanized camera brings a high degree of automation to the preparation of typed listings for directories and similar material. Known as the Listomatic Camera Model 1, it was developed by the Eastman Kodak Co. and will be sold and distributed through existing organizations of the Commercial Controls Corp., Rochester, N. Y.

The new camera will rapidly photograph one, two, or three lines of typing from IBM or similar punched cards, at high speeds and in columnar form. The resulting film negative can be quickly and easily reproduced by photolithography or photoengraving.

A complete procedure for preparation of a list would involve the following: Copy is set on a Justowriter recorder in one, two or three-line increments. The recorder produces a proof and a by-product punched paper tape containing all the information keyboarded by the operator. Justification (obtaining even margin) can be obtained automatically by pressing a switch on the recorder which will insert a justification code at the end of each line. The tape containing all the listings is then fed into a Justowriter reproducer which sets the material automatically on continuous pinfeed tabulating cards as a medium rather than reproduction proof paper. When the tape has set a listing on a card, the line finder automatically advances the continuous cards to the first writing line of the next card in the exact position required from a code in the tape.

When a galley of continuous cards has been completed, they are removed from the reproducer and inserted in a special cutter manufactured by the Standard Register Co., Dayton, O., which die-cuts the cards into the exact tabulating size at the rate of 100 per minute. At this point, a file of cards containing the listings in the same order that they were typed on the recorder has now been created. These cards are then given to the key-punch operator who punches codes designed to tell the Listomatic camera whether the cards contain one, two or three lines, and which are used to control the camera's film advance so that there will be no variance in line spacing between entries. At this punch operation, the cards may also be code punched for future sorting through existing collators or sorters where it is desirable to sort out categories of cards or to sort in-and-

NEW high-speed Eastman Kodak Co. camera, right, can automatically photograph typed information contained on IBM cards at the rate of 230 photographs per minute. Complete system utilizing camera for preparation of listings would include the Justowriter recorder and reproducer of the Commercial Controls Corp., an automatic card cutter of the Standard Register Co., and suitable card punch and collating equipment of the International Business Machine Corp.

ROLL of developed film shows type of listing made by photographing the printing contained on individual cards. Through adjustments, the machine will picture the type at same size or in varying degrees down to half size.

out cards in which the listings change.

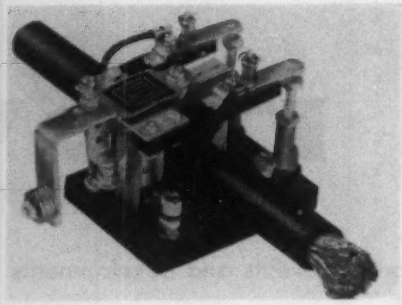
The cards are then passed through the Listomatic camera which photographs the listing at the rate of 230 cards per minute, regardless of whether the card is set in one, two or three-line listings. The camera is capable of photographing from the same size to a 50 per cent reduction. The resulting exposed film is in roll form and may be processed by a service bureau or any dark room equipped to handle films and reels. After developing, the galley negative of the listing now is stripped into page makeup, an offset plate or letter press high-etch plate is made, and the job is ready for the press.

AIRCRAFT and missile systems will receive greater emphasis in a staff reorganization recently undertaken by the Mechanical Division of General Mills, Inc. **Dr. Cledo Brunetti** presently director of engineering, research and development has acquired the responsibility for production engineering also. **Dr. Carl L. Kober,** radar and guidance expert, has been named associate director in charge of systems engineering, research and development. **Dr. John E. Barkely** formerly manager of physics and chemistry research has been named associate director of research and development. Dr. Brunetti is a leading authority on automation, particularly in the electronics field, and was a pioneer in printed circuits during his wartime work on the proximity fuse at the National Bureau of Standards.

Profile of Automation

NEED for recent expansion of the Snyder Tool & Engineering Co., Detroit, is the result of pressing requirements for adequate warehouse facilities to speed building of large new automated special machine tools. In announcing the expansion, **Howard N. Maynard,** president, explained that such items as electric motors, hydraulic equipment, etc., all have to be stocked in warehouses well in advance of actual building of the equipment.

As an example, a recent 165-ft long automated machine made by Snyder for the production of automotive transmission cases required the following items: 55 electric motors, 184 hydraulic valves, 73 hydraulic cylinders, 260 limit switches, 350 relays, 45 timers, 20 power units and 7000 ft of hydraulic tubing.



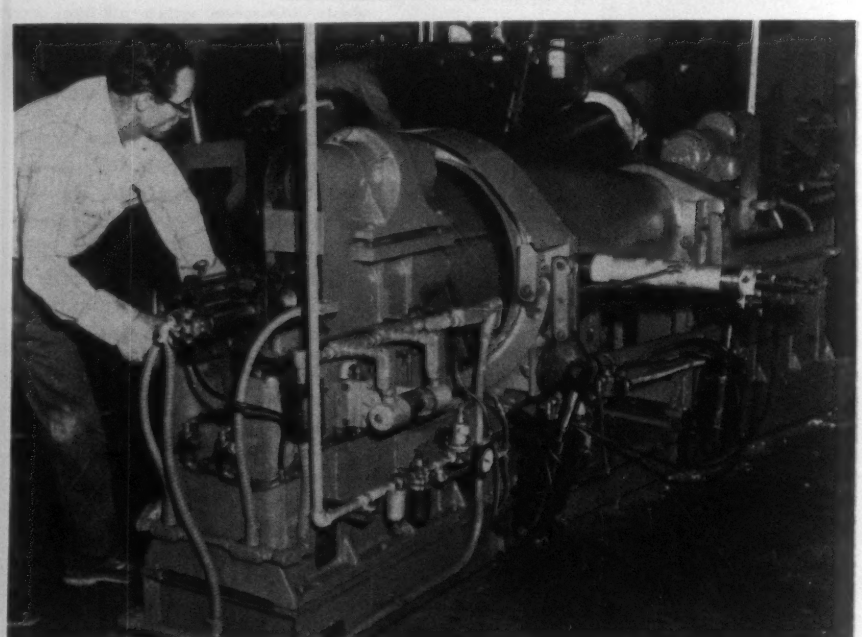
COILLESS relay, designed to function like a current transformer, has been developed by the Automatic Switch Co., Orange, N. J. The relays are used primarily for continuous welding operations. When so applied, the load cable connected to the welding electrodes passes through the relay and then, as a function of welding current, operates to control the motor feeding the material to be welded in a continuous operation.

Metalworking Survey Indicates Profit Margin Decline

IN A STUDY covering 73 metalworking companies in Chicago, Detroit and New York-New Jersey, the Commercial Discount Corp. of Chicago has found that while the industry is booming, profit margins have been slipping for the last five years. This is attributed to old equipment used by many companies, to the burden of carrying larger inventories, and to slower collections from customers.

The study brought out that about 58 per cent of metalworking equipment used today is at least 10 years old, and another 21 per cent is at least 20 years old. In that machines less than 10 years old are about a third more productive than older prewar machines, it is apparent that the use of older machines is a competitive handicap for many companies.

As to profit margins, the study found a steady decline in the metalworking industry. Net profit on sales for metal stamping plants, for example, declined from 6.5 per cent in 1950 to 3.0 per cent in 1955. In addition, inventories in the industry have increased. In 1950, a typical metalworking plant



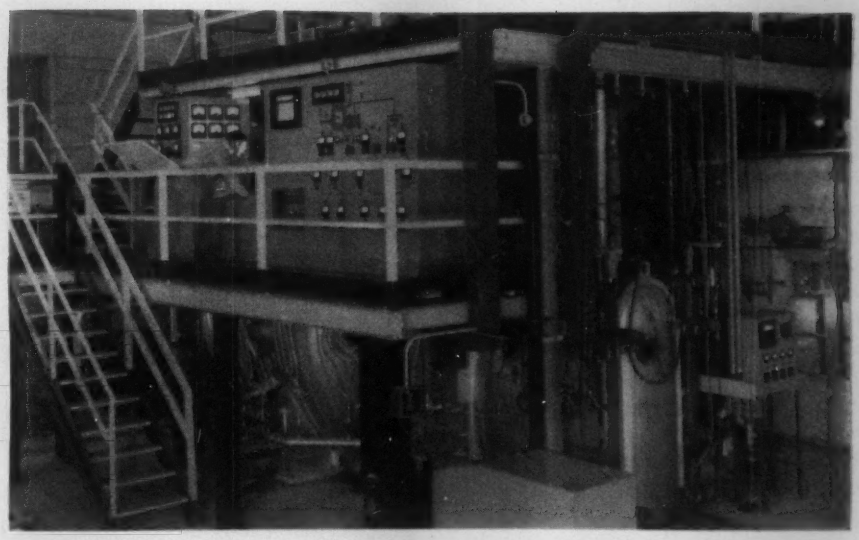
PRODUCTION of jettisonable fuel tanks for aircraft has been speeded up by a special purpose semiautomatic trimming machine engineered by Pastushin Aviation Corp. of Los Angeles for their own use. The automatic sequenced machine trims edges of the elliptical, complex-contoured tank in helping to achieve a production of 200 tanks per hour. The unit indicates to smaller shops the practical advantages which can be realized by combining miscellaneous inexpensive components in achieving more automatic operations.

carried inventory equal to about 65 per cent of working capital. In 1955, the study reports, inventory had grown to 80 per cent of working capital. At the same time, the average collection period on payments from customers has slowed down from 31 days in 1950, to 39 days in 1955.

The Commercial Discount Corp. has, over the past two years, carried out an experimental financing plan with 12 metalworking companies in plant modernization. The plan covered three elements: (1) To provide cash for metalworking companies to buy new equipment and pay for it on a deferred basis out of earnings; (2) cash to finance any larger inventories required by increased business. (3) immediate cash for a company's accounts receivable so that the delay of 39 days in collections would not hold up company operations. The successful results over the past two years have now led Commercial Discount Corp. to make this package financing plan available to more companies in the industry.

INCREASED importance of semiconductors to modern industry is reflected by a recent promotion at Texas Instruments Inc., electronic and geophysics firm. J. E. Jonsson, president of the firm, has announced promotion of **Mark Shepherd, Jr.** from assistant vice president to position of vice president in charge of the Semiconductor Products Div.

Shepherd has served progressively with Texas Instruments as project engineer, assistant chief engineer, and chief engineer for semiconductor products. In 1953 when the Semiconductor Products Div. was formed, he was appointed general manager and assistant vice president in charge. He is a senior member of the Institute of Radio Engineers and also active in the Society for the Advancement of Management, the American Management Association, and Armed Forces Communications Association.



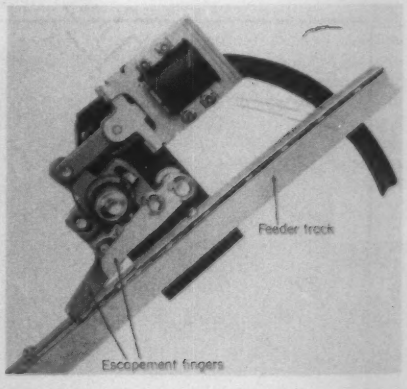
NEW vacuum melting furnace indicates advances made over the last ten years in this type of operation. This new furnace is remotely operated by the melter, who can control from one console the charging, mold transfer, and pouring operations. The design makes it possible to charge, melt, pour and remove ingots without affecting the vacuum in the melting chamber. The mold handling mechanism makes it possible to cast ingots of varying size and shape, either singly or in multiples from a single heat. The furnace is in operation at Vacuum Metals Corp., Syracuse, N. Y., a company jointly owned by Crucible Steel Co. of America and National Research Corp.

Standards Book Available

AMERICAN Standards Association has published a 60-page booklet designed to help the user and prospective purchaser of items in the electrical engineering area. *The 400 American Standards In The Electrical Field* also gives briefs of each of the current International Electrotechnical Commission recommendations and a listing of all projects under the jurisdiction of the Electrical Standards Board including officers, sponsors and scopes of these projects. The booklet may be obtained free from the ASA.

Electrostatic Photography Advances Graphic Arts

NEW method of producing images or printed characters on any paper, wood, metal, plastic or other surface coated with an inexpensive photoconductive pigment, has been developed by the Radio Corp. of America. Called the Electrofax system, the process involves a coated surface which is charged electrically for exposure before ex-



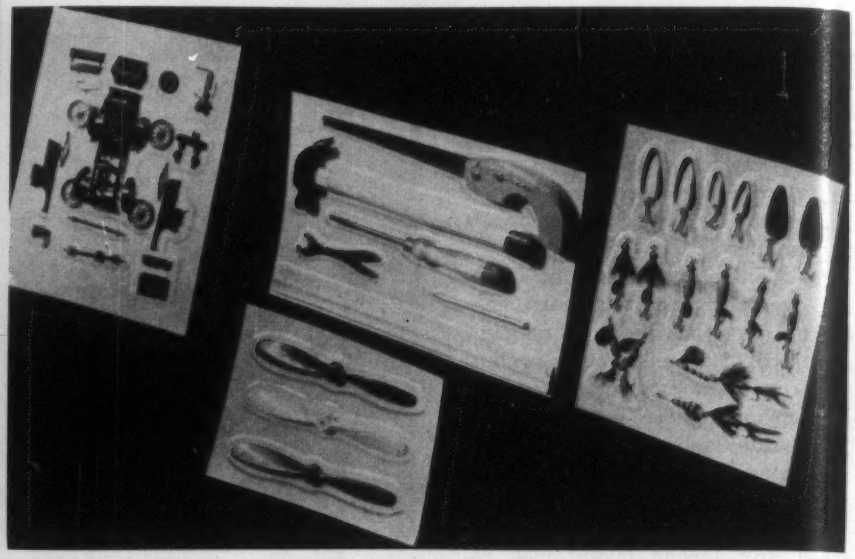
STANDARDIZED parts escapement unit has been designed for use on new installations or when converting existing installations to automatic parts feeding. This standard unit can be attached to any point along the feed track. Spring loaded fingers automatically release the individual parts and no special slots or track junctions are required. Manufactured by the Dixon Automatic Tool, Inc. the unit will automatically release up to 200 parts per minute, one at a time. The escapement fingers can be shaped or formed to accommodate any piece part up to 3 inches in diameter, and are available for solenoid or air cylinder operation.

posure to a light image by any of the conventional photographic procedures. The image is then developed with resin powder applied by a magnetic brush, and is fixed in permanent form by fusing under heat. The entire process, carried out with hand-operated equipment, can produce a finished permanent print in a fraction of the time normally required. By use of mechanized procedures, this time may be further reduced. The process can be applied to production of printed circuits.

In describing the system, **Harold G. Greig** of the technical staff of RCA Laboratories, reported that a coating with an indefinite shelf life is first applied to the plate to be used in printing. A coated plate may be stored in ordinary room light or daylight until it is required for use. After the coated surface has been sensitized by electrostatic charge, the light image to be printed is applied to the surface by direct projection, by contact exposure through a positive or negative transparency, or by exposure in a photoengraver's process camera.

As in all Electrofax applications, exposure to light reduces electrostatic charge in proportion to the intensity of the light, thereby leaving an electrostatic image on the coated surface. This electrostatic image is developed by brushing the surface with resin powder carried on a magnetic brush. Particles of the powder cling to the areas where the charge remains, corresponding to the dark areas in the original image, and the result is a reproduction of the original image on the surface of the plate. Tonal graduations are reproduced automatically by this process, since the powder is deposited most heavily in the areas that were darkest in the original image. At this point in the process, the image on the plate may be erased, altered, or added to, since the powder has not yet been permanently fixed by fusing—a process carried out by a few seconds of exposure to heat.

The prepared plate can then be swabbed with a chemical mixture that leaves the fused image areas receptive to greasy inks and the coated background areas receptive to water for a typical offset printing job, or the plate can be prepared for etching by standard photoengraving methods.



TRANSPARENT film of plastic holds parts to be packaged snugly to a display board or cardboard backing in new method developed by Comet Industries of Franklin Park, Ill. The company manufactures several sizes of completely automatic, semiautomatic and manually operated plastic vacuum forming machines necessary in applying the plastic envelope to the package. Type of package provides a visual display of item, a protective coating for the product, and lowers packaging costs by elimination of boxing.

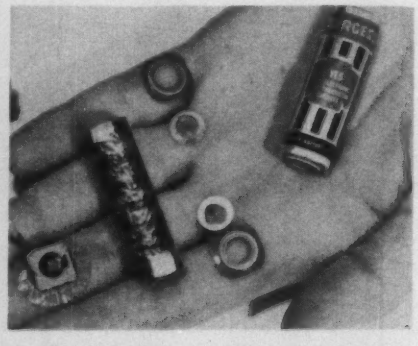
Government-Owned Patents

MANUFACTURERS and business men have been urged by the Business & Defense Services Administration, U. S. Dept. of Commerce, to make wider use of the government's *Index of Patented Inventions* to stimulate the national economy. The index, containing brief descriptions of over 21,000 inventions, has been placed in the Public Search Room of the U. S. Patent Office on the first floor of the Commerce Bldg., and thus made readily accessible to all who wish to examine it.

The index contains informative descriptions of approximately 5000 government-owned patents which usually can be made available without payment of royalties. The file also covers some 16,000 additional inventions which have been licensed to one of the federal agencies and can be obtained on a license basis from the inventor or present owner of the patent.

Forecasts For 1956

PROSPECTS for the business outlook in 1956 have been reviewed by the Economic Forum of the National Industrial Conference Board. A summary of the Forum's views was presented by **Martin R. Gainsbrugh,** Chief Economist of the Board: "For aggregate GNP,



NEW dry battery has been introduced by the Burgess Battery Co., Freeport, Ill. The battery is made by unique machine methods developed as a result of three years' research by the company. The illustrated battery is capable of producing 22½-volts and, as is shown, is built up of wafer cells sealed in airtight envelopes. Welded or soldered wire connections between cells are eliminated by the use of silver wax, a new conductive wax intercell connection which permits the construction of a series circuit merely by stacking the cells in a column.

Where your Conveyor Lines "Lift or Dip"...

Products move steadier with

Weld-Bilt AUTOMATIC ELEVATORS

• For Multiple Levels on One Floor — Weld-Bilt Automatic Conveyor-Lift Elevators

Lift or lower packages or parts from one level to another, automatically selecting certain packages, passing others, without manual attention. Adjustable tilting platforms, product-operated switches. Continuous operation, with automatic "traffic-jamb" stops. Any capacity, any height, with controls to handle any situation.

• For Multiple-Floor Conveyor Lines — Weld-Bilt Automatic "Vertical Transportation"

Designed for steady between-floor conveyorizing — one, two, or three floor levels. Highly versatile in application for completely automatic loading, unloading, lifting or lowering — with limit controls, brakes, inclinable or mechanized platforms, selector push button in any combination to suit your product and conveyor system.

If your production flow can benefit by Weld-Bilt AUTOMATIC "Lift or Dip" ELEVATORS, write for the help of an experienced Weld-Bilt Materials Handling Engineer for suggestions — without obligation, of course.

Pioneers in Automatic "Vertical" Handling

"Weld-Bilt" PRODUCTS

See our exhibit at the MATERIALS HANDLING SHOW June 5-8 Booths 210-212 — 309-311

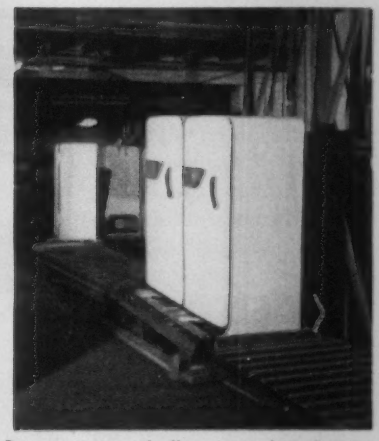
As pioneers in the automatic vertical transportation of materials, West Bend Engineers have had wide experience and acquired the "know-how" necessary to insure economical disposition of your material handling problems . . . "know-how" that can smooth out *your* production flow — multiple-level or floor-to-floor. They're at your service for advice, suggestions and plans — without obligation, of course. Just drop a note.

WEST BEND EQUIPMENT CORPORATION

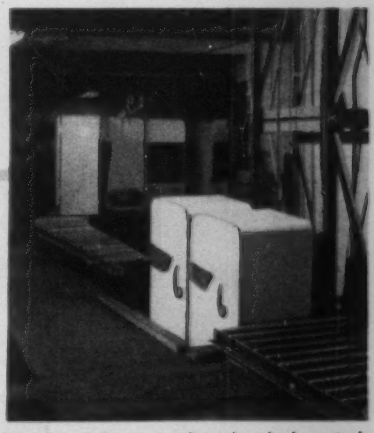
MATERIALS HANDLING ENGINEERS

347 Water Street • West Bend, Wisconsin

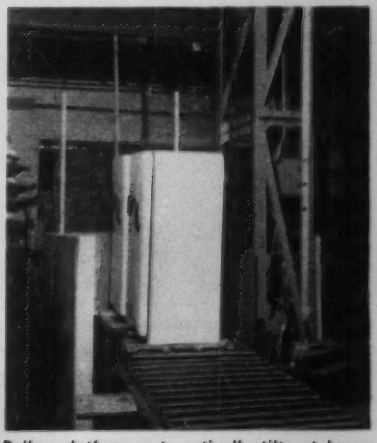
Typical Weld-Bilt Floor-to-floor Transportation



Freezers automatically conveyed to elevator on top floor. Automatic stops on conveyor hold two more freezers for next load.



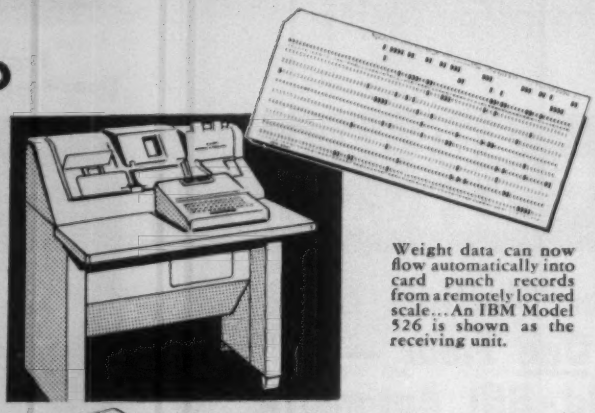
Weight of freezers trips electrical controls to start elevator descent to lower floor.



Roller platform automatically tilts at lower level to discharge freezers to moving conveyor. Empty elevator starts up instantly as load is released.

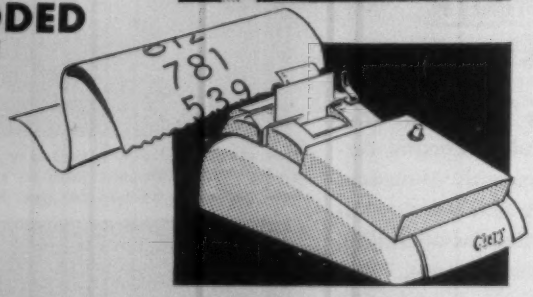
New REMOTE WEIGHT RECORDS

TABULATED



Weight data can now flow automatically into card punch records from a remotely located scale... An IBM Model 526 is shown as the receiving unit.

ADDED

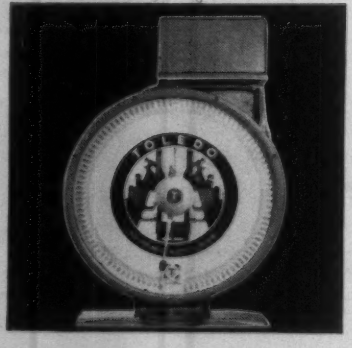


Weight records can be transmitted to an adding machine and printed on the tape and inserted tickets with ability to totalize weight on the tape. Clary Model 1972 shown.

DIGITAL INDICATION

A completely new concept of weight indication! From a remotely located scale, illuminated digital weight-indication is obtained.

by TOLEDO ELECTRONIC WEIGHT CONTROL



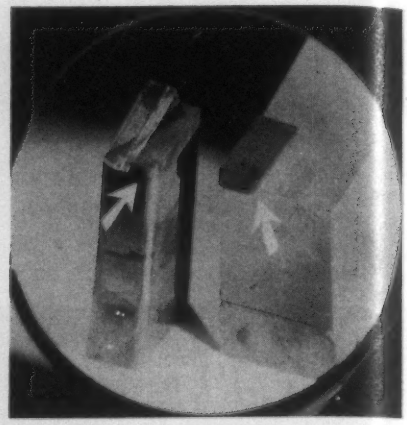
The weight indication passes through a Toledo digital scanner and electronic counter and translator to provide an accurate signal that operates these remote devices to bring weights anywhere in the form most useful to you.

Through Toledo's new electronics system of remote data handling, weight data is no longer limited as to form, or close proximity to the point of origin. Weights can now go anywhere . . . and appear in tabulated, added, recorded, or digital-indicated form. This greatly extends the capabilities of TOLEDO-mation throughout production, and assures maximum cost control accuracy.

What is your weight control problem? Write for bulletins on new Toledo remote digital-indication and recording.

Toledo Scale Co., Toledo 1, Ohio.

TOLEDO® *Headquarters for* **SCALES**

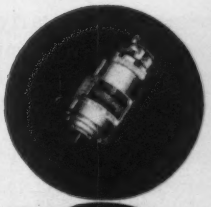


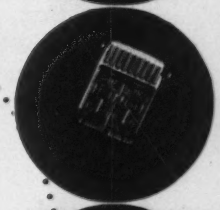
INDICATION of the wear life of cemented oxide cutting tools in comparison to carbide tools is illustrated by tests conducted by the Carboloy Dept. of General Electric Co. Cemented oxide tip, right, made a cut of 111 inches in about 36 minutes of cutting time in turning a 5¾-inch diameter of 1045 steel motor shaft. The work was run dry at a speed of 900 sfpm, with a depth of cut of 0.100-inch and feed set at 0.005-inch. The carbide left, normally used on the job under the same conditions ran less than half a minute and provided a cut of only ¾-inch. Wear life of cemented oxide was estimated as 25 times better than the carbide.

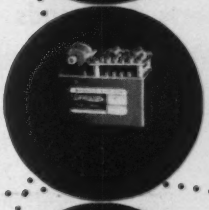
the Forum anticipates a first-half total of $400-$405 billion. The consensus is for a further mild increase in the second half, to $405-$408 billion. Our consensus is for virtually full employment throughout 1956. The Forum anticipates only about 2.5 million unemployed in the first half, and perhaps a slightly lower level of unemployment in the second half.

"On price trends the all-commodity wholesale price index was indicated in the consensus to be up 1.5 points. The Forum believes the consumer price index will remain virtually where it is, perhaps only a half point change during the course of the year. The year 1956 as a whole will yield the highest economic activity, the largest national output, and the greatest volume of industrial production this nation has ever known. However, the direction of many of the significant and sensitive economic indicators may be either neutral or down toward the close of 1956.

"Elements of strength as we enter 1956 include: the hard core for expansion—namely the upsurge in private investment; further accumulation of inventories; the pressures of population, result in an increase in state and local spending





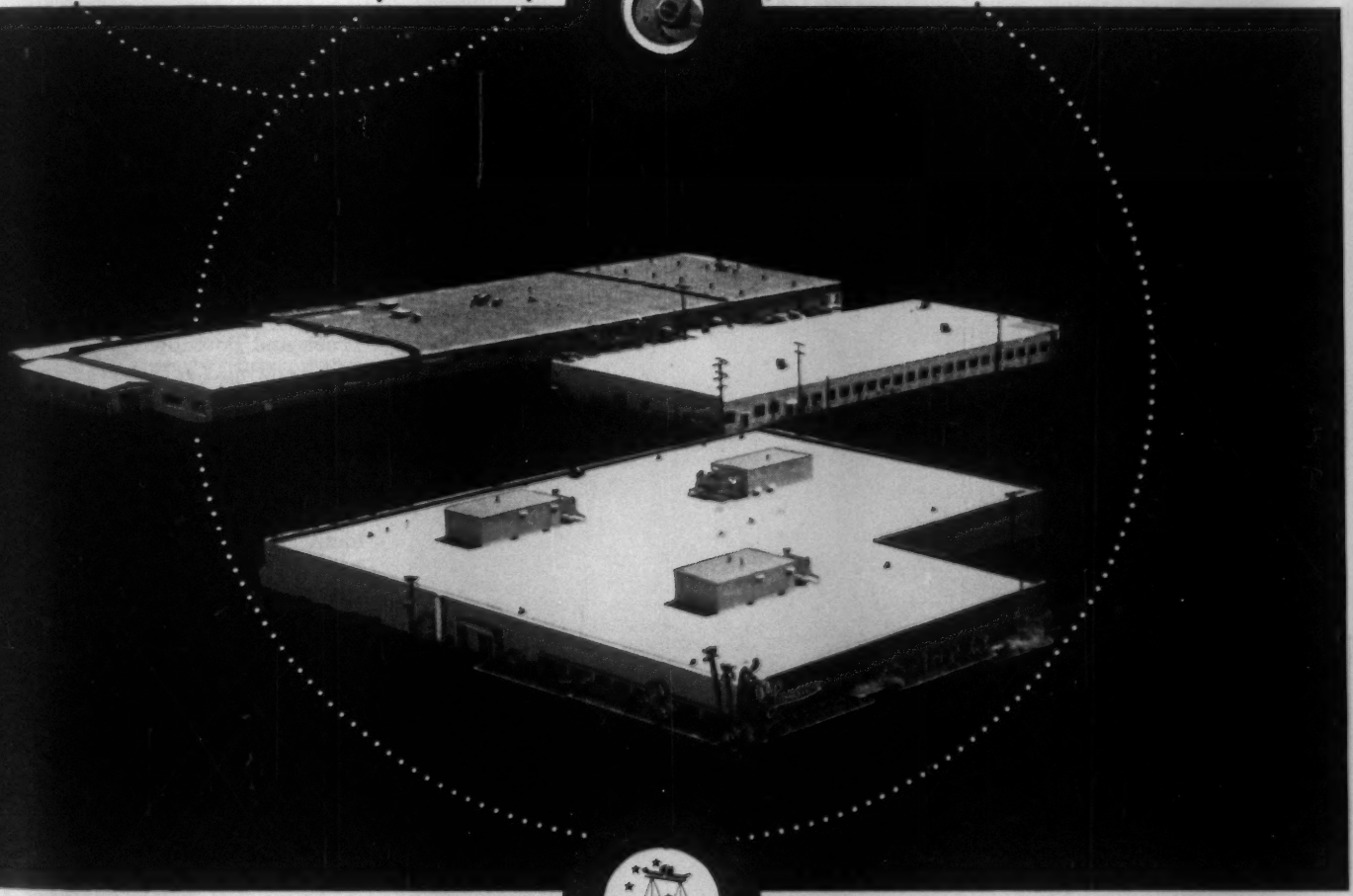


The Capacity for Achievement

Since 1937 Librascope has earned and achieved—on an ever expanding scale—a position of leadership in the design, development and manufacture of computers, automatic controls and data handling systems for military and industrial applications.

Librascope, through a unique combination of electronic, magnetic, mechanical and optical techniques, consistently demonstrates an outstanding facility for the production of precision instrumentation and devices.

The creative ability of an exceptional engineering staff and the production capacity of a superbly equipped 200,000 sq. ft. plant facility can be focused on *your* computer-control problem. Consult Librascope today.



ENGINEERS . . . *learn about Librascope's new creative "Project Development Teams"* . . . *write Mac McKeague, Personnel Director*

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of $400 or $500 million per quarter; and the possibility of tax relief.

"Emphasis was laid upon the fact that this boom is maturing; that by mid-1956 it will be at least two years old and there are increasing signs of strain and stress; and that the second half will require close and careful watching."

A member of the Forum, **L. J. Paradiso,** Assistant Director-Chief Statistician, Office of Business Economics, U. S. Department of Commerce said in part: "The maintenance of a high rate of capital investment throughout 1956 can be expected. . . The demand for goods and services has fully kept pace with the rising capacity . . . The recent upsurge in demand has resulted in strong pressure being placed on existing capacity. . . . Businessmen expect plant and equipment expenditures to continue to rise in the first quarter of 1956 . . . The seasonally adjusted total is estimated at $32 billion in the first quarter, compared with $31 billion in the fourth quarter of this year.

"Increases over fourth-quarter rates are indicated by manufacturing firms, particularly the durables —iron and steel, machinery and automobiles, and by railroads . . . Other industries, commercial, public utilities, mining and nonrail transportation, have indicated little or no change . . .However, the first quarter of 1956, on the basis of our survey, shows a slowing down in the rate of increase experienced in the last nine to twelve months."

Reports On Trends In Material Handling

BEFORE stepping down as president of the Material Handling Institute, R. H. Davies, vice president, Industrial Truck Div., Clark Equipment Co. has reported a stepped-up pace among conveyor manufacturers that will undoubtedly continue through the early part of 1956. Many engineering layout estimates are in the hands of purchasers who are contemplating early 1956 purchases of large conveyor systems integrated with fully automatic production lines. There is a trend toward closer engineering co-operation between conveyor manufacturers and machine tool builders.

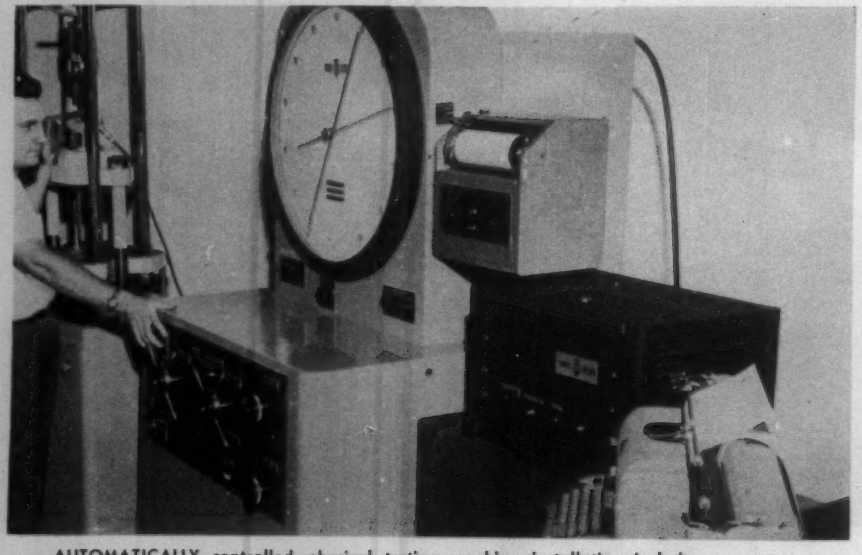
Davies also reported that two very important concepts are becoming more and more prominent in the material handling field. The first is the increased emphasis on unit loads and potential savings realized through unit loads. The second is increased emphasis on making maximum use of cubic space. Both of these factors will influence the purchase of all types of material handling equipment.

George G. Raymond, Jr., presi-

dent of the Raymond Corp., was elected president of the Material Handling Institute to succeed Davies. Raymond attended Cornell University and has served as sales manager and vice president in charge of sales for the Raymond Corp. He was elected president in 1955. He has also served as president of the Association of Lift Truck and Portable Elevator Manufacturers, and as director and first vice president of the Material Handling Institute.

Other newly-elected officers and directors of the Material Handling Institute are: John W. Stiles, president, Island Equipment Corp.; R. L. Fairbank, sales manager, Towmotor Corp.; George Greenberger, president, Sage Equipment Co.; M. W. Heinritz, vice president, Gould-National Batteries; Howard Palmer, vice president, Lewis-Shepard Products Inc.; L. C. Daniels, vice president, Allis Chalmers Mfg. Co.; W. E. Duchene, manager material handling sales, Heppenstall Co.; A. C. Timmons, sales manager, Lift Trucks Inc.; and J. W. Wunsch, president, Silent Hoist & Crane.

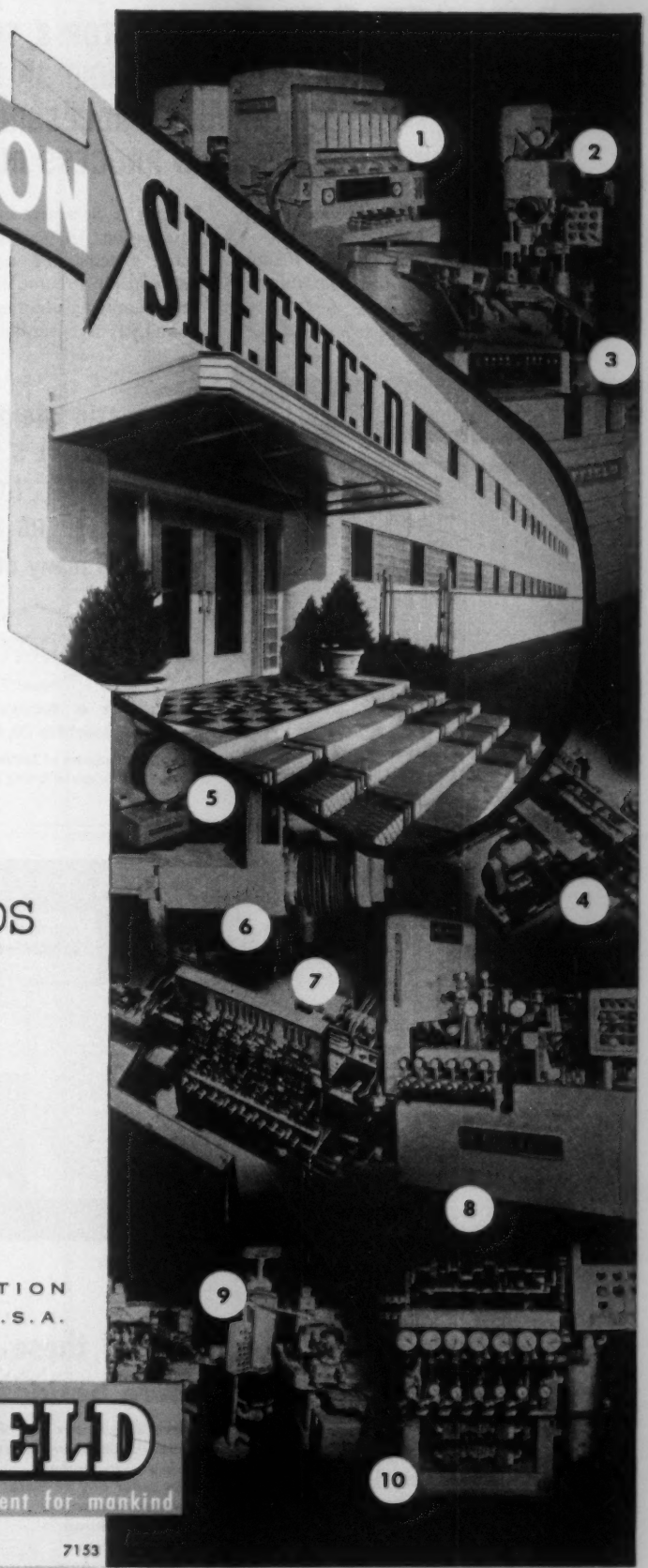
Hamilton Beatty, assistant general sales manager, the Austin Co., in speaking before the Material Handling Institute, had this to say: "Our problems, as designers and builders of new plants for which we frequently select and instal



AUTOMATICALLY controlled physical testing machine installation includes an automatic typewriter for printing test results; the system has been developed by the Tinius Olsen Testing Machine Co., Willow Grove, Pa. The operator merely inserts the specimen and starts the machine. Preset controls minimize the time required to conduct the successive tests and insure uniformity of testing procedure for any number of tests with similar specimens. A separate electric typewriter automatically prints the yield strength for the selected percentage of offset, plus an identifying test number as each specimen is tested. Yield strength or other test data is determined immediately without time consuming interpolation of a stress-strain curve. If desired the printing unit can be located at any distance away from the actual testing area.

AUTOMATION

AND
AUTOINSPECTION
SYSTEMS, CIRCUITS
AND CONTROLS
HAVE BEEN OUR
BUSINESS FOR
MORE THAN A
DECADE. IT
WILL PAY YOU
TO CHECK YOUR NEEDS
AGAINST SHEFFIELD
EXPERIENCE



WRITE DIV. 510 FOR BULLETIN NO. AU-1154

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1. Gaging cylinder bores for selective assembly
2. Controlled honing of gear blank bores
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6. Post-process size control of bearing races
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8. Controlling 12 grinding machines
9. Controlling bore size of pinion blanks
10. Automatic gaging of crankshaft main bearings

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Automatic Conveyor Systems... Automatic Cotton Batting Systems... Pre-forming Feeds... Textile Blending Systems... Automatic Range Drying Systems... these are only a few of the successful entries made by Proctor & Schwartz into the field of automation. In planning your automatic systems and equipment, why not consult Proctor first? We have been supplying automated equipment to industry for over half a century.

PROCTOR AUTOMATION AT WORK

PROCTOR CONTINUOUS CONVEYOR DRYER AT NATIONAL YEAST COMPANY

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and many others

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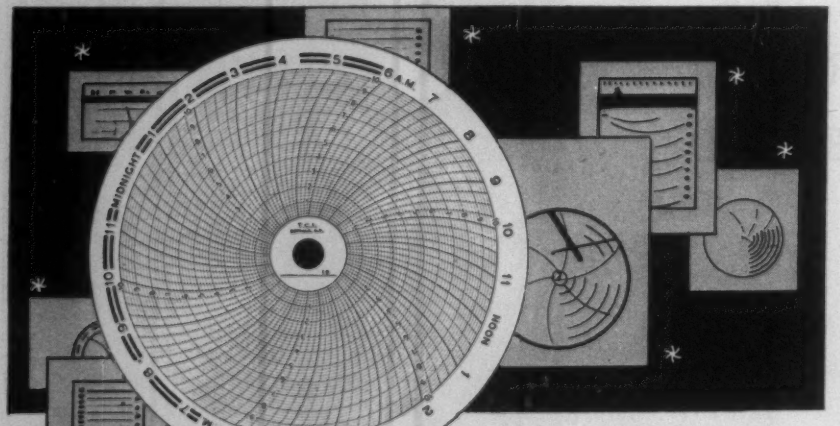
Philadelphia 20, Penna.
Manufacturers of Textile Machinery and Industrial Drying Equipment



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material handling equipment, is to apply our accumulated experience plus the special knowledge of people like yourselves, to give our common customer the plant best suited in all respects to his current and future needs. From you manufacturers, we need fewer catalogs and more case histories. We need to know not only what work a machine will do, but what that work will cost. We also need to know the basic conditions under which the machine will operate at the cost indicated."

J. F. Rafferty has joined Pneuma-Serve Inc. as vice president and general manager. The company supplies automated fastener feeding equipment to industry. **N. B. Burdette,** formerly manager of field engineering has been named chief engineer and **E. J. Knitter,** formerly project engineer, has now become production manager of the firm.

MEETINGS AND EVENTS

Feb. 8-10—

Western Joint Computer Conference. To be held San Francisco, Calif. Additional information may be obtained from B. J. Bennet, Stanford Research Institute, Stanford, Calif.

Feb. 16-17—

Purdue University. Materials Handling Conference sponsored by Department of Industrial Engineering in conjunction with Indianapolis Chapter of the American Materials Handling Society to be held University Campus, Lafayette, Indiana. Additional information may be obtained from H. T. Amrine, Department of Industrial Engineering, Purdue University, Lafayette, Indiana.

Mar. 12-15—

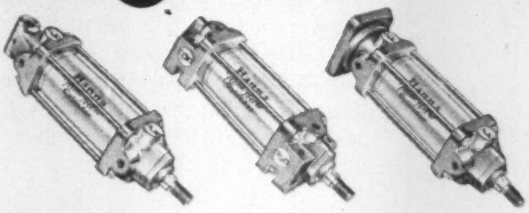
National Electrical Manufacturers Association. Mid-winter meeting to be held Edgewater Beach Hotel, Chicago. Additional information may be obtained from Association Headquarters, 155 E. 44th St., New York 17, N. Y.

Mar. 14-15—

American Society of Mechanical

For Dependable Power and Control...

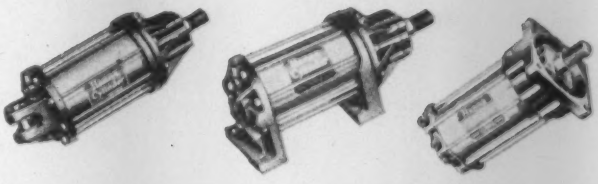
Hanna
FLUID T750 SERIES POWER CYLINDERS



The new Hanna T750 Series cylinders are the last word in smooth, dependable performance. These rugged, compact cylinders are built for air operation to 250 p.s.i. and oil or water operation to 750 p.s.i. Many mounting styles and interchangeable heads make these cylinders exceptionally versatile. Available in 1½", 2", 2½" and 3" diameters.

WRITE FOR CATALOG 750A

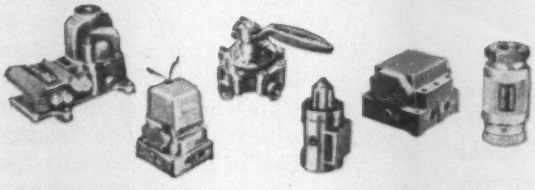
Hanna LP
AIR & HYDRAULIC CYLINDERS



For low pressure air and hydraulic operation. Thousands of varied applications have proved the quality and reliability of these Hanna cylinders. Bore sizes range from 4" to 14". These cylinders, combined with Hanna T750 Series cylinders, offer a complete range of cylinder sizes and mounting styles. Made in any practical stroke length.

WRITE FOR CATALOG 236B

Hanna
AIR AND HYDRAULIC VALVES



Designed to provide most efficient control for Hanna cylinders — ideal for other fine control jobs too. Many types available for hand, foot and electric operation, speed control, pilots and master for automatic and remote control.

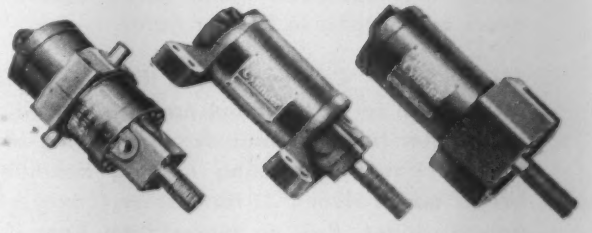
WRITE FOR CATALOG 254

Hanna Filters, Lubricators, Regulators, Traps

These accessories provide complete protection for precision-built cylinders and valves—will keep maintenance costs at a minimum.

Write for Catalog 105

Hanna HP
HYDRAULIC CYLINDERS



Hanna HP cylinders are without equal for strength, precision and power. For operating pressures up to 1500 p.s.i. Bore sizes range from 1½" to 8" in a complete selection of mounting styles. Heads are fastened directly to the cylinder tube, giving clean appearance.

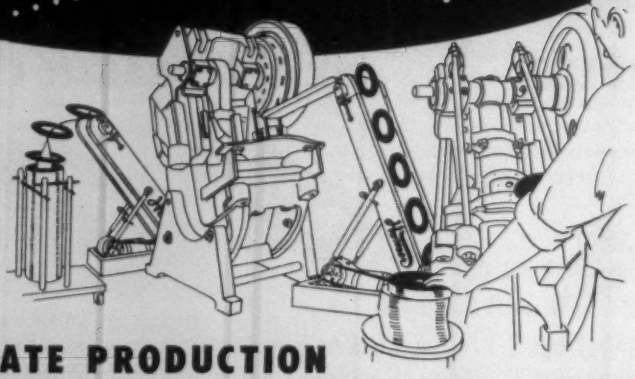
WRITE FOR CATALOG 233B

Hanna Engineering Works

1753 Elston Avenue • Chicago 22, Illinois

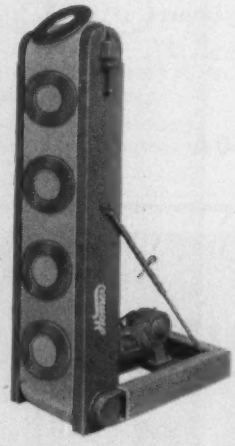
HYDRAULIC AND PNEUMATIC EQUIPMENT — CYLINDERS — VALVES — RIVETERS

HOMER MAGNETIC CONVEYORS AND MAGNETIC SHEET SEPARATORS



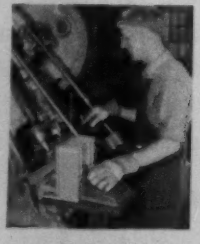
AUTOMATE PRODUCTION
CUT LABOR COSTS—REDUCE REJECTS
in handling ferrous parts and scrap

Homer "Space Saver" Permanent Magnetic Conveyors cut costs by automatically feeding machines . . . stacking parts . . . transferring parts between machines . . . and performing parts turn-over and other handling operations.



"Space Savers" convey ferrous parts at angles up to 90° without belt cleats, buckets or holding devices. The powerful magnetic assembly securely holds and conveys—ends loss of parts from belt as a result of belt resilience or bouncing over belt cleats—prevents damage to critical finishes caused by parts riding against cleats or jamming in flapper gates.

"Space Saver" Conveyors save floor space because their steeper inclines (up to 90°) without nosed-over delivery . . . and resulting shorter length permit closer grouping of machinery. "Space Savers" have outstanding loading flexibility—any angle, any height above floor . . . from other conveyors, chutes or production machines. Pick up pieces from floor if required. Standard and Custom models available . . . Write for Bulletin MC-250.



HOMER PERMANENT MAGNETIC SHEET SEPARATORS

Speed handling of steel sheets and pieces. Prevent scratching or marring of surfaces in handling. As each piece is removed, next piece rises clear of stack for easy handling. Write today for Bulletin SS-210.

THE HOMER MANUFACTURING CO., INC.

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FIRST IN INDUSTRIAL PERMANENT MAGNETIC CONVEYORS

Engineers. Engineering Management Conference to be held Hotel Statler, St. Louis, Mo. Additional information may be obtained from Society Headquarters, 29 West 39th St., New York, N. Y.

Mar. 15-16—

American Institute of Industrial Engineering. Fifth Annual Spring Conference of Cleveland Chapter to be held Cleveland, Ohio. Additional information may be obtained from W. S. Ritchie, Room 300, Cuyahoga Savings Bldg., 2123 East 9th St., Cleveland 15, Ohio.

Mar. 19-21—

Society of Automotive Engineers. National Production Meeting and Forums to be held Hotel Statler, Cleveland, O. Additional information may be obtained from Society Headquarters, 29 West 39th St., New York 18, N. Y.

Mar. 19-22—

Institute of Radio Engineers. National Convention to be held Waldorf-Astoria Hotel and Kingsbridge Armory, New York. Additional information may be obtained from Society Headquarters, 1 East 79th St., New York, N. Y.

Mar. 19-23—

American Society of Tool Engineers. Industrial exposition to be held in conjunction with 24th Annual Convention in International Amphitheatre, Chicago. Additional information may be obtained from Richard Gebers, 10700 Puritan, Detroit 28, Mich.

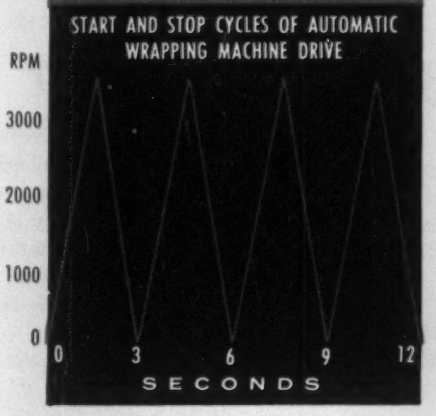
Mar. 21-23—

Illinois Institute of Technology. Eighteenth Annual American Power Conference to be held at Hotel Sherman, Chicago. Additional information may be obtained from Illinois Institute of Technology, 35 West 33rd St., Chicago 16, Ill.

Mar. 30-31—

University of California. Joint meeting of Western Section of the Operations Research Society of America and Los Angeles Chapter of the Institute of Management Sciences to be held Los Angeles

20 ROLLS OF "SARAN WRAP" EVERY MINUTE



The Dow Chemical Company's production of "Saran Wrap" has leaped from 130,000 rolls to 4,000,000 rolls a month since 1951. This up-swing is due to a new plant, a new flow system, and additional equipment including new machinery equipped with Reliance V★S Drives.

One of the most dramatic applications of V★S Drives is on the final wrapping machines shown here. The drives must be able to start, accelerate to 3500 rpm., and stop more than 20 times a minute.

The most important feature, though, is not the frequent starts and stops, but the delicately controlled acceleration of the drives. "Saran Wrap" is only 1/6th as thick as a human hair, and sharp or jerky starts will cause a break in the sheet and halt production. Reliance Drives do the job day in and day out without a single break due to uncontrolled acceleration.

This feature of V★S Drives, called *Dynamic Response*, is only one of the many facets of Reliance Drives. V★S Drives can regulate tension, synchronize operations, control speed rates, and automatically program speed changes.

Whether you handle a thin film of plastic or steel billets, on a complete production line or a single machine, Reliance can give you better quality, more production, and lower costs through Variable Speed Drives. D-1506

Write for bulletin D-2311.

RELIANCE V★S DRIVE ®

RELIANCE ELECTRIC AND ENGINEERING CO.

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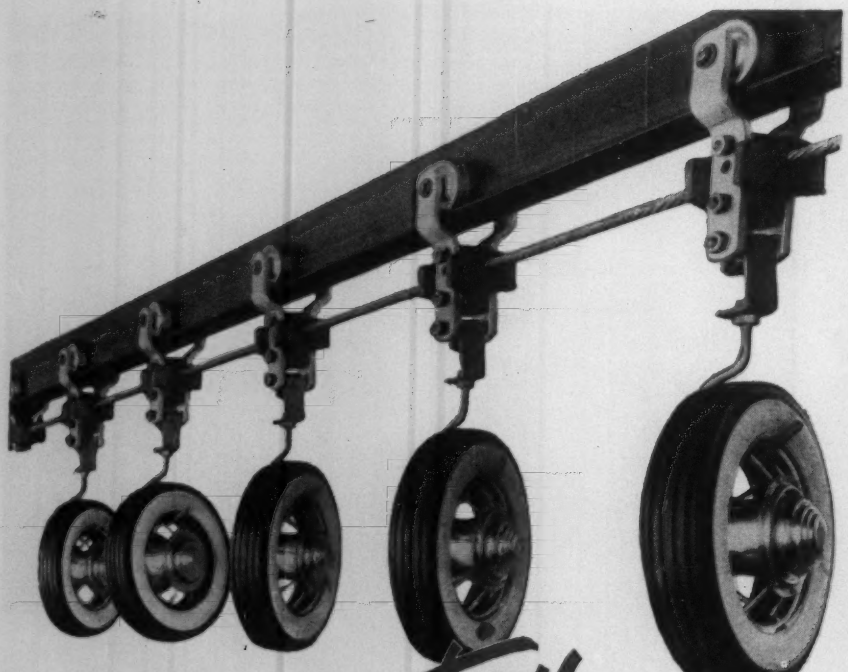
Canadian Division: Welland, Ontario

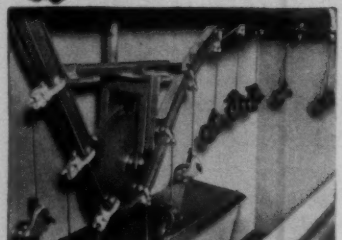


Production going your way on Buschman Cable Conveyors

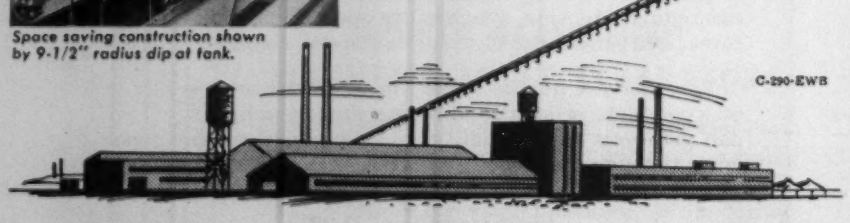
These streamlined pre-engineered conveyors have no equal in economy, flexibility and application. Designed for light and medium loads, they will operate continuously with minimum adjustment and maintenance.

Fabricated from stocked component parts, Buschman "Universal" cable conveyors permit "customized" installations at standard prices. Their compact construction . . . shorter radius turns and dips . . . save production space.

If low-cost production is your goal . . . Buschman is your conveyor! The E. W. Buschman Co., 4544 Clifton Avenue, Cincinnati 32, Ohio.



Space saving construction shown by 9-1/2" radius dip at tank.



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World's Most Complete Line of Conveying Equipment

BUSCHMAN CONVEYORS

GRAVITY CONVEYORS • LIVE ROLLER • BELT • SLAT • ETC.

Write for Bulletin 40 for complete details.

campus. Additional information may be obtained from University of California Extension, Engineering, Los Angeles 24, Calif.

April 9-12—

American Management Association. Twenty-fifth National Packaging Exposition and Conference to be held Convention Hall, Atlantic City, N. J. Additional information may be obtained from Association Headquarters, 330 West 42nd St., New York 36, N. Y.

April 10-11—

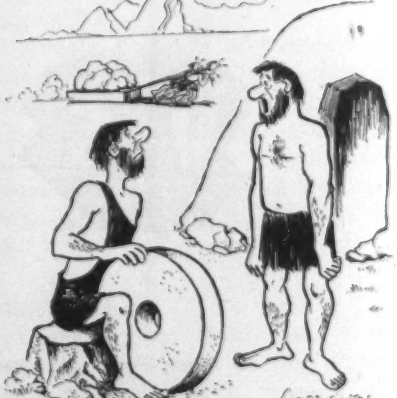
Midwest Research Institute. Symposium for management on applications of analog computers to be held University of Kansas City. Additional information may be obtained from Midwest Research Institute, 425 Volker Blvd., Kansas City 10, Mo.

April 18-20—

Illinois Institute of Technology. Armour Research Foundation sponsored conference on industrial research to be held on university campus. Additional information may be obtained from Illinois Institute of Technology, 35 West 33rd St., Technology Center, Chicago 16, Ill.

April 26-27—

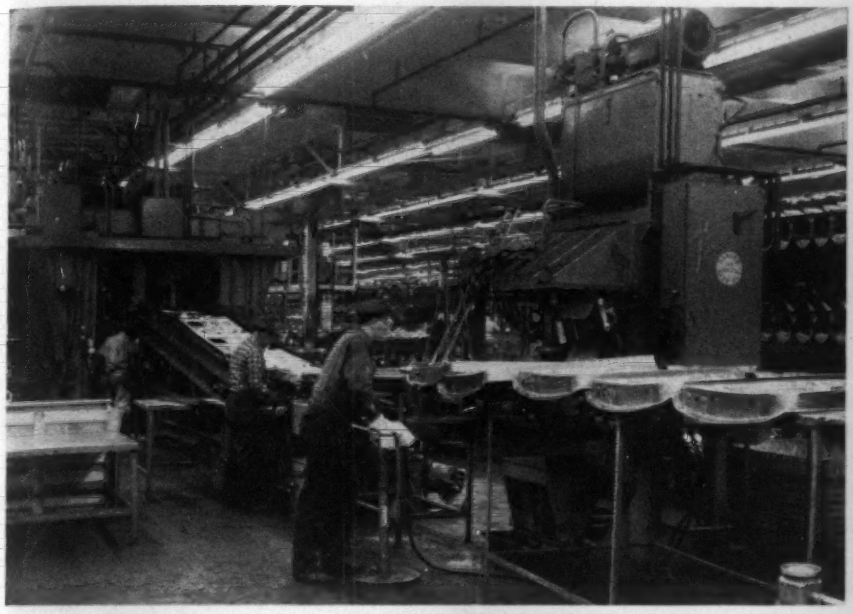
American Institute of Electrical Engineers. Conference on recording and controlling instruments to be held Bradford Hotel, Boston. Additional information may be obtained from Institute Headquarters, 33 West 39th St., New York 18, N. Y.



"But, Oogla, don't you realize that this thing of yours will put thousands out of work?"

detroit dateline

By JAMES C. KEEBLER
Associate Editor



Automated lines carry automobile body stampings through welding operations at Ford Motor Co. Cleveland Stamping Plant. Conveyors and transfer devices link welding operations with presses

IT TAKES ENGINEERING

SOME INDUSTRIALISTS seem to have the impression that automation is something for which you send a purchasing agent out for a boxful. Certainly the automakers do not show evidence of this misconception. Engineering here is no longer confined to horsepower under the hood. Horsepower on the production floor must be properly employed or money is wasted.

A Name for It?

Some call it production engineering. Some call it process planning. Some call it manufacturing engineering. Others place it in industrial engineering. Yet, whether handled by the master mechanic's department or the automation engineering department the problem is spherical.

No matter what angle they view it from, all automakers see the same thing. Constant engineering effort must be employed at the task of devising production operations and sequences that are as automatic and economical as advanced know-how provides.

The methods engineer of yesterday made micromotion studies of an operator's actions in order to simplify the work and save effort and money. The automation engineer of today is studying operations required in a production sequence. Can this job be done better by an automatic cycling machine? Can these automatic cycling machines be linked to form an automatic line? Can these automatic lines be integrated to achieve automated production?

Broad Field

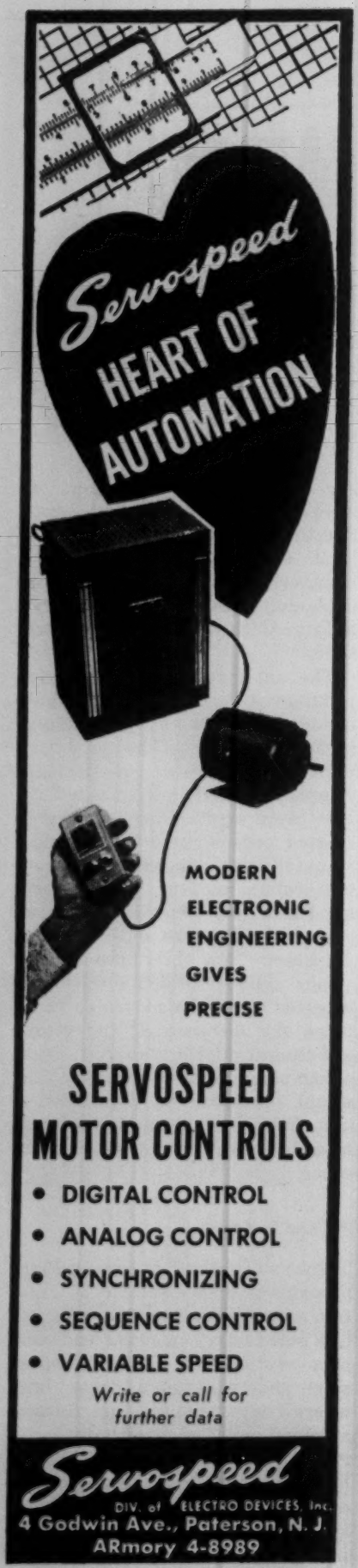
As these questions imply, the automation engineer is involved in activities of considerable scope. Besides a thorough background of manufacturing techniques he must also know his equipment and the components of which it consists. Specification of standard lines of limit switches, electrical relays, pneumatic and hydraulic components simplifies maintenance problems and thereby minimizes downtime.

The automation standardization program at Ford's Cleveland plants include: (1) Engine plant No. 2 uses hydraulic oil as the motivating power for transfer mechanisms, whereas formerly air-actuated devices were used. Engineers standardized on one type of hydraulic actuator which turns oil pressure into rotary motion. (2) Stamping Plant uses two-to-one air-powered drive units in most transfer machines. New units have a short-stroke cylinder which propels the transfer device on moveable racks twice the distance of the stroke and thus at double the speed. Mechanism uses half the air volume that would otherwise be required. A unit from one automatic device is interchangeable with that from another.

A Case In Point

Ford's Cleveland Stamping Plant provides a good example of automation engineering at work. In this new factory intricate and complex automation devices speed steel sheets through press lines where body stampings are formed, stamped, cut and trimmed.

Designed to eliminate heavy, laborious and hazardous working conditions, the automation devices set the heavy, unwieldy stampings into presses with pinpoint accur-



acy; reach into the presses to extract them, and then move them to the next operation. Each piece is automatically turned, twisted or inverted when necessary, thus sparing the operators the burden of lifting or carrying bulky parts.

Handling devices and presses are cycled by new drop-cam electric controls. These insure split-second timing needed for the high speed automatic devices. All automation is wired to a press-control circuit and a single downward sweep by a driver arm sends all units into action at precisely the correct moment. Employees guide the stampings and adjust pieces where necessary.

Automation engineers have also carried their skill into welding operations. Stampings from two or more lines are conveyed simultaneously into electric welding machines where they are joined into finished body parts. In addition, such operations as sandblasting and undercoating of hoods are incorporated in the stamping line.

All automation equipment has been standardized to permit easier maintenance with interchangeable parts. Maintenance time is cut to a minimum so that machines can be utilized more fully and effectively.

The responsibility of finding easier and more efficient methods of moving approximately 3000 tons of cold-rolled steel through the plant daily is delegated to the automation department.

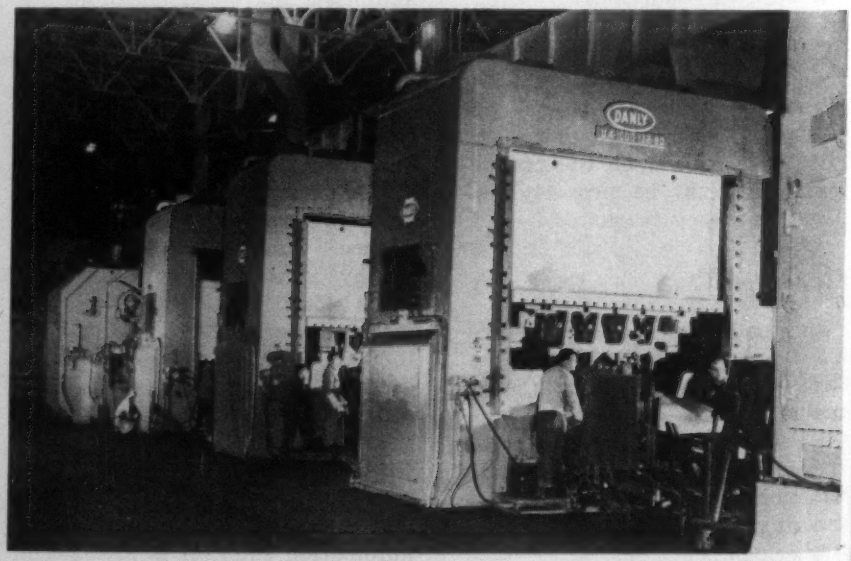
Harry Ashton, manager of the automation department, has a staff of engineers, designers and experienced journeymen who conceive, design, construct, test and maintain all automation in the plant. This department takes over when it is decided to automate a certain production process within the plant.

The idea goes to designers who work out such details as clearances and dimensions and also to electrical engineers who design suitable circuits. Complete engineering facilities are available for this work in the department.

When completed, new devices are checked in the shop and then taken to production sites and installed. They are tested by the automation experts under actual working conditions and any necessary changes are made before the devices are turned over to production crews.

The automation department's preventive maintenance program begins immediately after the devices have been installed.

Certainly manufacturers of all types are wise indeed to copy a page from the automaker's notebook and establish competent automation engineering assistance on a full time basis. In today's factory it is important that the production processes be well engineered.



Passenger car hoods move down one of the 22 major press lines at Ford Motor Co. Cleveland Stamping Plant. Each piece is automatically turned, twisted or inverted when necessary, sparing the operator the burden of handling bulky parts

Progress and Obsolescence

In their zeal to increase markets for products, many businessmen in recent years have unfortunately emphasized a negative approach. Not a few uncomplimentary remarks are heard concerning the popular comment about "forced obsolescence". As a result, fear that automation's advance will necessitate forced deterioration of products to assure continuing markets has arisen in some quarters.

There should be no confusion over the real issue. While it is a forced obsolescence from one point of view, from the other it is nothing more than straightforward continuous advance in design know-how. This is largely a matter of attitude. The fact must be recognized that no perfect product is possible. Only through a continuous program of production, research, evaluation, study, and redesign can our products be gradually improved and perfected. And such progressive design improvement is practically and economically attainable only by conservative steps or stages.

It is a known fact that today's products are far superior to those of bygone years. Functional design is superior, operation simpler, serviceability much improved and cost more reasonable. It is easy for users to recall the long life of products of the past and forget the failures and breakdowns. Continuous improvement has reached the point where near perfection is expected but negative talk about obsolescence makes a few failures assume altogether disproportionate importance in many eyes.

In our development of increased markets and wider distribution it would be well to emphasize progress and advance in design, not obsolescence. There is real merit in advance; talk of forced obsolescence only raises unwarranted fears of deceit.

EDITOR

AUTOMATION

Importance of maintenance increases in direct proportion to the degree of automation. In this modern automated production line, as in chemical, petroleum, and power plants, this increased importance is evident. As in other highly automated industries, the operator is provided with indicating equipment as aids in the detection of trouble or potential trouble which will require maintenance

Courtesy, Plymouth Div., Chrysler Corp.

By **NAPOLEON PERKOWSKI**
Industrial Engineering Dept.
University of Southern California
Los Angeles, Calif.

INDUSTRIAL ENGINEERING CAN AID IN

DEVELOPING A MAINTENANCE PROGRAM

Successful control of the maintenance function in an automated plant can be advanced if management recognizes several basic facts —maintenance is a complex problem for which no quick or simple solution exists, and the successful techniques used in controlling production offer an excellent guide to the methodology of controlling maintenance

CURRENT literature stresses the growing importance of the maintenance function to the automated plant. To the executive who is attempting to intelligently steer his plant into the automated future, but who is presently faced with maintenance problems, it is with no little concern that he contemplates increasing maintenance requirements.

But brighter aspects of the problem are in evidence. Various plants have intelligently and vigorously approached the problem, and have developed relatively successful maintenance programs. However, in no case was the goal achieved without attendant difficulties. Successful techniques, when summed up for a given plant, appear obvious and straightforward but there is a limitation as to what can be conveyed by the printed word; this leads to the need of repeating an often-repeated warning—one must be cautioned about seeking a

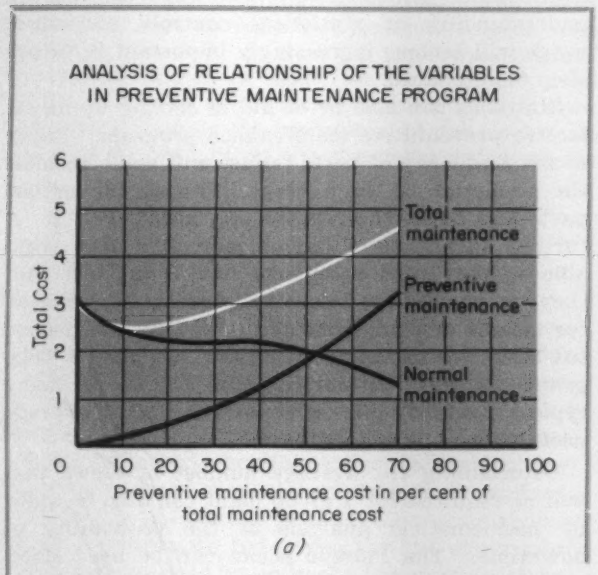
quick solution by copying some other plant's program. The economics of any maintenance program are dependent upon individual situations found in a given plant. The requirements for maintenance vary from industry to industry, and to make matters more complicated, the requirements will vary from plant to plant in the same industry. Consequently, each plant will have to tailor its own particular program to its own particular requirements, *Fig.* 1. This article covers some of the less obvious considerations in tailoring a program to a particular plant.

If management accepts the fact that a ready-made, quick solution is not to be found, then the basis is laid for approaching the problem in a manner conducive to finding a successful solution. An open, inquiring mind is more capable of realizing the value of the proved techniques of administration, measurement and control developed for the less neglected phases of a manufacturing operation but readily applicable to maintenance.

As a first consideration, it should be borne in mind that the most painstaking and well-planned course of action cannot be successfully executed without the co-operation of the interested parties. The persons who are affected by the course of action must be convinced that it is a workable plan, but dealing with the intangible factors of morale and salesmanship is not a simple matter. It is necessary to stimulate not only the operating and administrative personnel of the maintenance department, but also top management whose co-operation is a requisite to the success of the program. This is only too frequently forgotten by technical personnel who are trained to think in terms of clear-cut solutions. In that top management determines the ultimate course of the business enterprise, the need for their co-operation and approval is obvious. A clear understanding of the function and reasons of the plan by the operating personnel will prevent the rise of rumors, misunderstanding, and general dissatisfaction.

Balanced Program Is Necessary

The beginning of any program can well be with appreciation of the help to be gained from applying industrial engineering techniques to the problem. Many large companies have pioneered in the use of industrial engineering methods in the maintenance department. However, in many cases a balanced program involving all of the available techniques is not utilized. It is found that while in one company a good systems procedure for paperwork control will be established, the program will be



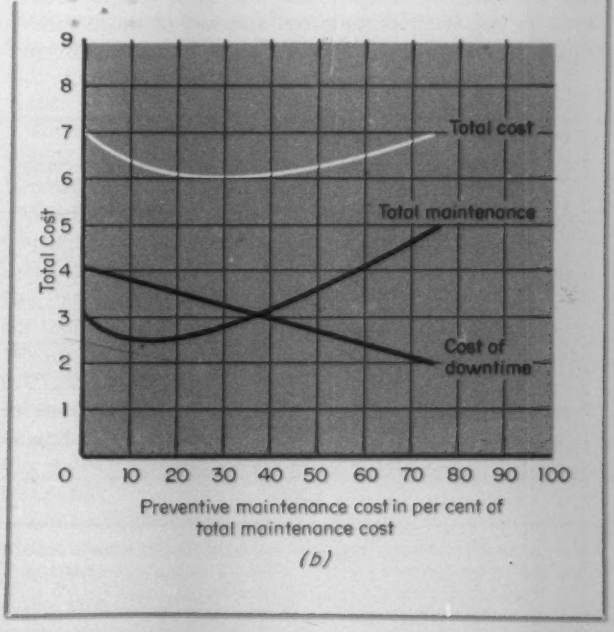


Fig. 1—Analysis of cost variation with varying preventive maintenance effort is of value in maintenance economics. For these charts the abscissa is preventive maintenance cost in per cent of the total maintenance cost; the ordinate is total cost. A typical variation of total maintenance cost with increasing preventive maintenance effort is shown in graph (a). Normal maintenance refers to maintenance operations which are required after the performance of preventive maintenance operations. Theoretically, normal maintenance would be 0 at 100 per cent of preventive maintenance. Note the small increment change in normal maintenance in the 20 to 40 per cent range although the cost of preventive maintenance continues to increase.

Graphical analysis (b) relates total maintenance effort and cost of downtime in defining a theoretical minimum maintenance curve. The downtime curve represents the cost due to the loss of production as a result of equipment failure. Idealized, this is expressed as a straight line and will decrease until 100 per cent of preventive maintenance at which point downtime cost should be theoretically reduced to 0. The total cost curve is the sum of the cost used in the first and second curves

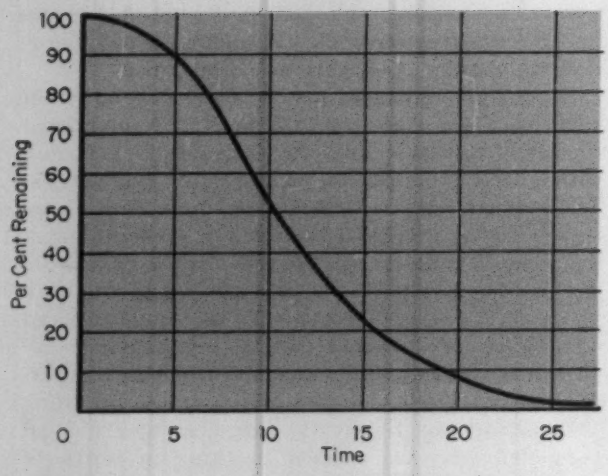


Fig. 2—Determination of mortality data for key parts will aid in establishing an effective preventive maintenance program. A typical parts survivor curve is shown. From this type of graph, it is possible to predict the replacement needs of critical parts from the average life span indicated

lacking in utilization of work measurement and statistical techniques. This occurs because too often many individuals who acquire training in one particular discipline will tend to favor its application and, in extreme cases, a person will tend to feel that his technique or discipline is a solution to all problems. Industrial engineering disciples exhibited this tendency in the usage of time and motion study in the early development of the field. It was their feeling that a panacea had been found for all of the shop difficulties but that such was not the case is obvious. The answer, as experience has shown, lies in the integration of various management techniques.

In some cases it may be found that one technique may be too costly or impractical, and therefore, applicable in limited cases; while in other cases it may be discovered that the use of a single technique is insufficient and that the use of more techniques is necessary. Maintenance management in the area of automation must be alert to the potential in all of the management techniques and tools available.

A brief look at some industrial engineering techniques might assist in clarifying the discussion. Statistical quality control offers a substantial tool for control of maintenance operations. For example, a machine output may be controlled for quality by the typical average and range control charts. If points on the chart are out of control due to assignable causes, it may mean that the trouble lies with the machine and not with the adjustment of the machine. Thus a continuous check of the control chart would enable maintenance personnel to trouble shoot for elimination of the assignable causes falling in the maintenance sphere.

On the basis of the observable fact that with automation there is a decreasing need for production personnel but an increasing need for skilled maintenance personnel it is also apparent that an understanding of statistical controls and their usage will become increasingly important in future shop maintenance.

Statistics can also be of aid in setting up an effective preventative maintenance program. Study of the frequency of parts failure will make possible the prediction of the average life span for critical parts and hence the replacement needs, *Fig.* 2. A further advantage of having mortality data available on parts and equipment lies in the fact that they can be used for determining group depreciation for classes of equipment as allowed by the income tax laws. For instance, American Telephone & Telegraph Co. has had considerable success in using typical mortality curves in estimating the average useful life of telephone poles.

Determining the average number of crews that will be required for a given plant can also be aided by mathematical analysis of the probability of downtime. The Poisson series can be used effectively in determination of this probability of downtime. For example, in a plant having a large number of machines, it is possible to set up convenient tables which will give the expected frequency in working days of the simultaneous major break-

Number of major breakdowns occurring	Probability of exactly that number occurring *	Number of days in year event expected to occur
0	.301	80
1	.362	93
2	.216	57
3	.087	23
4	.026	7
5	.006	2
6	.002	1
Check	1.000	264

*Assumed average working year of 264 days and average value of expected number of breakdowns in that period as 1.2. Probabilities taken from mathematical tables giving individual terms of Poisson for $c' = 1.2$.

Fig. 3—Use of the Poisson distribution is possible in determining the probabilities of occurrence of an exact number of events in a large population when the probability of this event happening to an individual is small. This table illustrates the expected frequency of major downtimes in equipment, based upon a calculated or assumed daily average of 1.2 breakdowns for a normal work year of 264 days. The area for the opportunity of occurrence of downtime in any one calculation must be constant; that is, known days when equipment is especially subjected to less or extreme use must be taken into consideration if such use is extraordinary. From the chart, it can be predicted that on 80 days of the year no major breakdown will occur; on 93 days of the year one breakdown will occur, and on 57 days, two breakdowns will take place, etc.

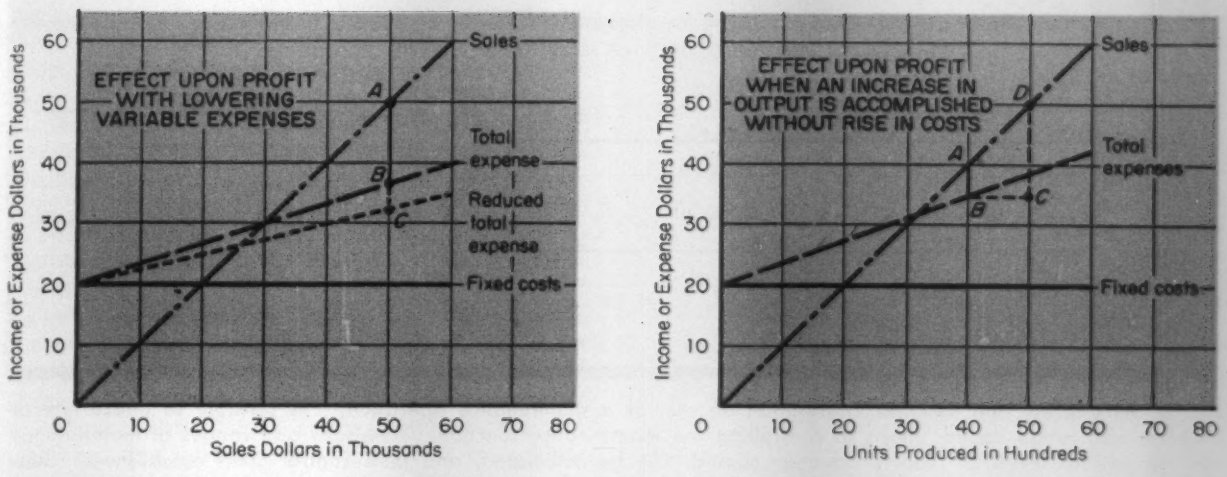


Fig. 4—Effectiveness of any program within a plant can by measured primarily by two dimensions: (1) By the amount of money saved as a result of the operations of the particular program or (2) by an increased volume of output without an increase in cost. Both dimensions can be illustrated by means of break-even charts. In chart (a), line *A-B* represents profits at a given sales volume; with reduced expenses, increased profit is represented by line *A-C*. In chart (b), profit from production of a given number of units is shown as line *A-B*; with increased production at same cost levels as with previous units, increased profits are represented by length of line *D-C*. In view of the increasing proportional representation of maintenance cost in the total cost figure, these charts illustrate the importance of cost control and a cost reduction program in the maintenance department and the need of an effective maintenance program

downs occurring within a given class of equipment. An example is shown in *Fig.* 3.

Advanced statistical techniques used in operations research are also applicable to the solution of many knotty problems in industry. The queueing theory, otherwise known as the waiting-line theory, is one of the statistical tools of operations research which has possible industrial application. Once the freqency of machine failure is determined, it will enable the prediction of an effective distribution of maintenance repairmen for the equipment. It also can be used to estimate the number of required repairmen prior to the collection of actual historical data.

Another important tool of operations research is mathematical programming which in maintenance applications permits the determination of the optimum inventory size of spare parts required for repairs. It might be mentioned that the industrial logistics research group at the University of California at Los Angeles is doing a considerable amount of work along the lines of applying mathematical programming to industry.

▶ Work Measurement Can Be Used

Another proved administrative tool, the industrial technique of work measurement, involves the establishment of standard methods and times for the performance of various tasks as determined by time and motion studies. The fallacy of the idea that maintenance work cannot be measured has been proved in large and small plant applications. As a mater of fact, it has been found that standard time data are particularly effective for many of the routine maintenance operations. Generally speaking, usage of work measurement gives better administrative control, points the way for improvements in operating techniques, and gives an effective control over the scope of the entire operation.

Measuring the output of direct labor is not the only way that work measurement may be used. With an increasing proportion of the labor cost going into the expense of indirect labor, work measurement techniques are slowly coming into use to measure these costs. However, as plants become more automatic, maintenance costs in the form of more skilled service technicians are increasingly responsible proportionally for greater indirect expenses as commonly measured. The long-run need for a new approach to costing practices is apparent in view of typical limitations of this type associated with more automatic operations.

But as in other departments, cost control provides the binding force necessary to control the function of the maintenance department, *Fig.* 4. The same basic tenets of cost control hold true for a maintenance department as for any other department within the plant. It is necessary to know the cost of a department before it is possible to control the cost or even attempt to reduce the cost. Without the knowledge of existing cost, it is very difficult to make any sort of plan which would lead to future cost reductions. Also, the maintenance department should be able to justify its cost to the top management on the basis of cost saved for the company.

The effectiveness of maintenance can be very well represented in the proportional decrease of downtime expense due to equipment failure. And since this cost can be measured, it behooves the maintenance department to utilize it in presenting

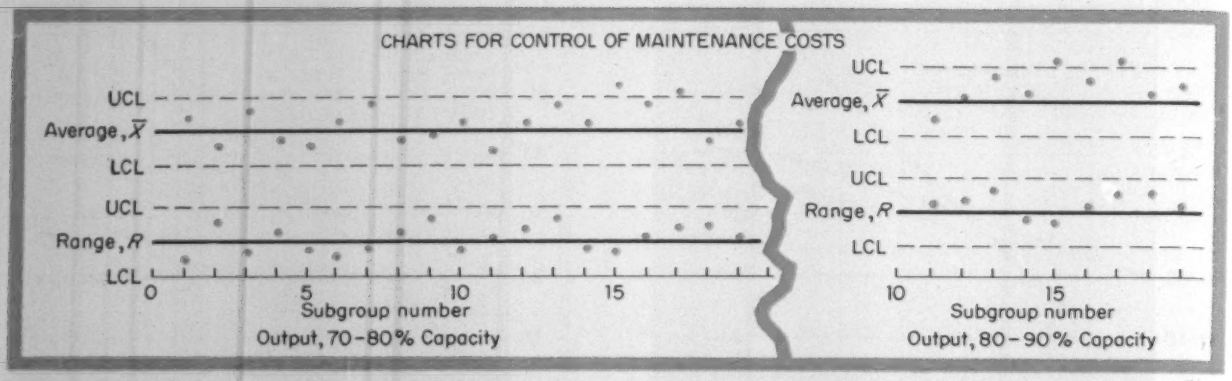


Fig. 5—With timely and detailed information on cost of a maintenance operation, it is possible to utilize typical average and range control charts in controlling the maintenance function. Averages and ranges of maintenance cost for several levels of plant production should first be calculated, and then control limits established. Subgroups can be plotted weekly on the basis of daily cost for a five-day week and will, therefore, represent an average daily cost of maintenance during a week. Points falling outside control limits will graphically call management's attention to the occurrence of a controllable situation which should be investigated

its monthly or yearly report of progress. Many plants measure the performance of the maintenance department by assigning a certain unit of measurement that correlates effort expended to the work load or output. In a steam generation plant, for example, man hours required are compared with the total number of steam pounds generated in a given period. This type of figure, though valuable for measuring the performance within a given plant, cannot serve as a common denominator for cost comparisons with other plants because, as it has been mentioned, requirements vary from industry to industry and will vary from plant to plant within the same industry.

From the viewpoint of cost control, the formation of a workable budget is most important. It should incorporate a reasonable future outlook of expected work volume and personnel requirements. Frequently, maintenance budgeting has been included under the manufacturing expense budget; it should have a sound internal departmental budget. The maintenance budget gives control over expenditures and affords an opportunity for analysis of cost at the end of the budget period to determine the cost variances. In general, a maintenance budget will include in its projected cost a breakdown of preventive maintenance, normal maintenance, and fixed maintenance expenses.

Normal maintenance should include maintenance charges which are neither preventive nor fixed maintenance costs. For example, the cost of unpredicted breakdowns, transfer of equipment and installation of new facilities would be representative of normal maintenance. Fixed maintenance can be classified as the maintenance of buildings, grounds and power plants. It is cost of maintenance which would exist if the plant were completely shut down and preventive maintenance were absent from the department.

Both preventive maintenance and normal maintenance will contain the elements of fixed and variable expenses. Although maintenance itself is considered in terms of plant cost as semivariable in nature, it is possible for analysis within the maintenance department to consider these costs as fixed and variable. Such a breakdown when adopted on a departmental basis, offers a clear-cut control over manpower and cost.

THE AUTHOR

Napoleon Perkowski, who holds a M. S. degree in industrial engineering granted by Illinois Institute of Technology, is presently associated with the industrial engineering department of the University of Southern California. The material in this article stems in part from research into the effect of automation upon the maintenance function, which the author performed in preparing his master's thesis.

His academic background has been complemented by industrial experience in a capacity as methods engineer with the Ford Motor Co., plant engineer with the City of Chicago Water Works Dept., and presently as consultant to manufacturing concerns in the metalworking and electrical fields.

▶ A Method of Cost Control

Inasmuch as maintenance costs are subject to the chance-cause variation, the author considers it possible to determine assignable causes of cost variations through the use of statistical control charts, *Fig.* 5. The statement that a chance-cause

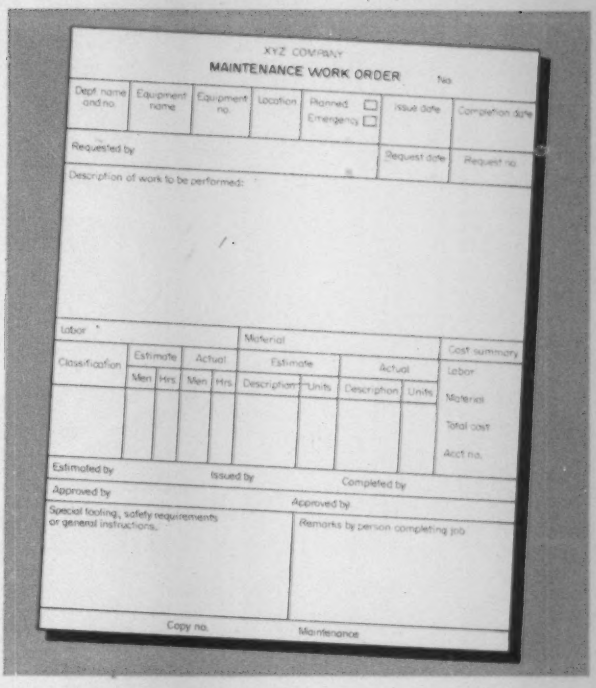
variation exists in the maintenance department means that certain variations will exist in the daily routine, however, occasionally, disproportionally high cost will result due to some definite assignable cause. It is the out-of-average cost in which maintenance management will be interested, for by knowing its cause, it will be able to prevent its occurrence in the future. It appears that it is possible to plot control limits for maintenance expenditure in a manner similar to that shown in *Fig.* 5.

For a given level of production, maintenance costs tend to remain constant; changes will occur when production output increases or decreases through a certain range, i.e., costs are semivariable in nature. Establishing control limits to the normal costs for various operating levels is possible. To avoid excessive administrative cost in determination of the control charts, it is best to plot a chart for a 10 per cent range of production output, thus only two charts normally need to be plotted, one from 70 to 80 per cent of output and another from 80 to 90 per cent of output. Upon the sufficient accumulation of weekly costs, it would be possible to predetermine the initial control limits when a plant is operating at a given percentage of output, and thereafter observe the variation of the cost which fall outside of the control range. Such a chart would provide maintenance management with an excellent tool for graphic determination of the cost variances with their department. Furthermore, the charts would necessitate the keeping of good and accurate records which would further improve the cost picture in the department.

The administrative tools of production planning and control offer means which should be applied to scheduling of maintenance within a plant. The Gantt charts, lead-time analysis for overhaul and repairs, and schedules for preventive maintenance can be used very successfully by maintenance management in obtaining the desired results from an operating force. Many companies specialize in commercial production of a variety of Gantt type charts which can be readily adapted for maintenance. With these aids it is possible to schedule the work of crews of individual crewmen and to plan a systematic overhaul of equipment.

▶ Data Provides Control

There appear to be few exceptions to the rule that a work order form should be used as a basis for maintenance work. The existence of a written order on a convenient form can aid in planning and accounting operations associated with maintenance. From the standpoint of providing room for posting of all information giving adequate descriptions, and providing a necessary flexibility, the work order should be of a regular 8½ by 11-inch letter size format, *Fig.* 6. These are not unimportant considerations, since it is obvious from all previous discussion that it is only with proper data that management can develop the tools that it needs in controlling maintenance. A consideration of forms


XYZ COMPANY

MAINTENANCE WORK ORDER No.

Dept. name and no.	Equipment name	Equipment no.	Location	Planned ☐ Emergency ☐	Issue date	Completion date
Requested by					Request date	Request no.

Description of work to be performed:

Labor					Material				Cost summary
Classification	Estimate		Actual		Estimate		Actual		
	Men	Hrs.	Men	Hrs.	Description	Units	Description	Units	Labor
									Material
									Total cost
									Acct. no.

Estimated by | Issued by | Completed by

Approved by | Approved by

Special tooling, safety requirements or general instructions:

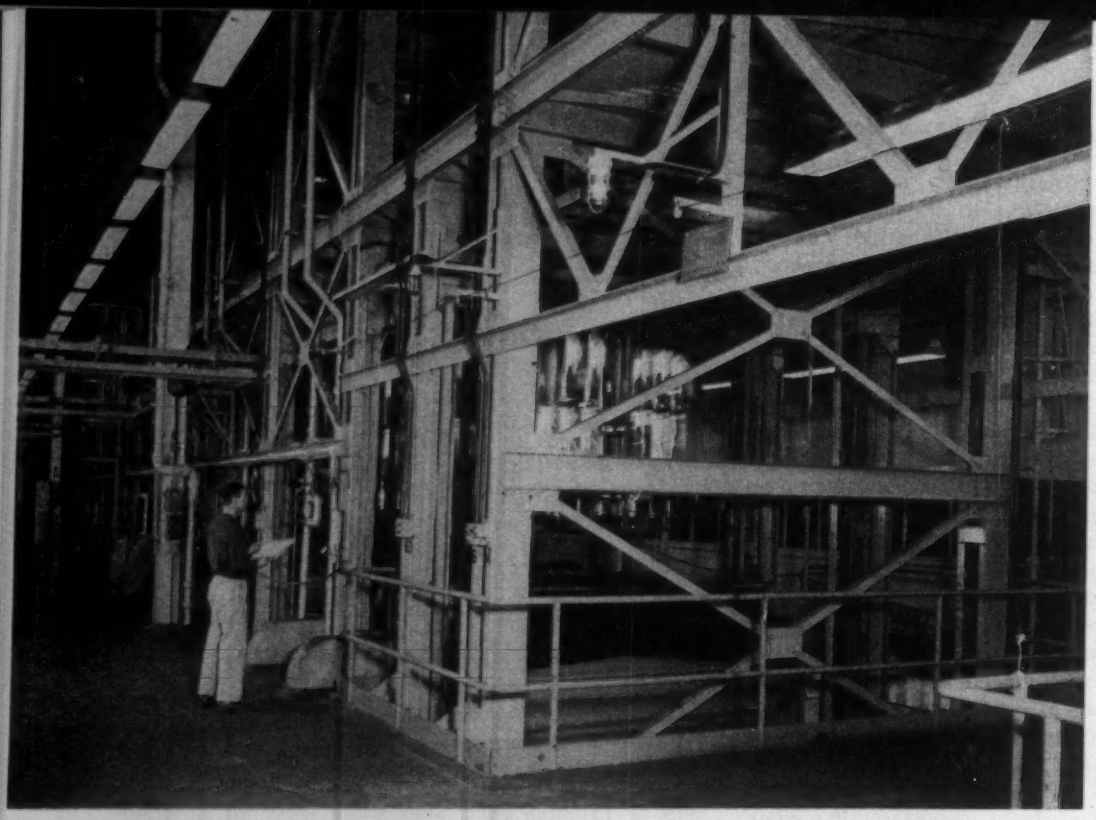
Remarks by person completing job:

Copy no. | Maintenance

Fig. 6—Example of a work order form for a formal maintenance program is shown. The form should be designed on standard size paper to permit the entry of all pertinent data, the accumulation of which is so important to the continually effective control of the maintenance operation

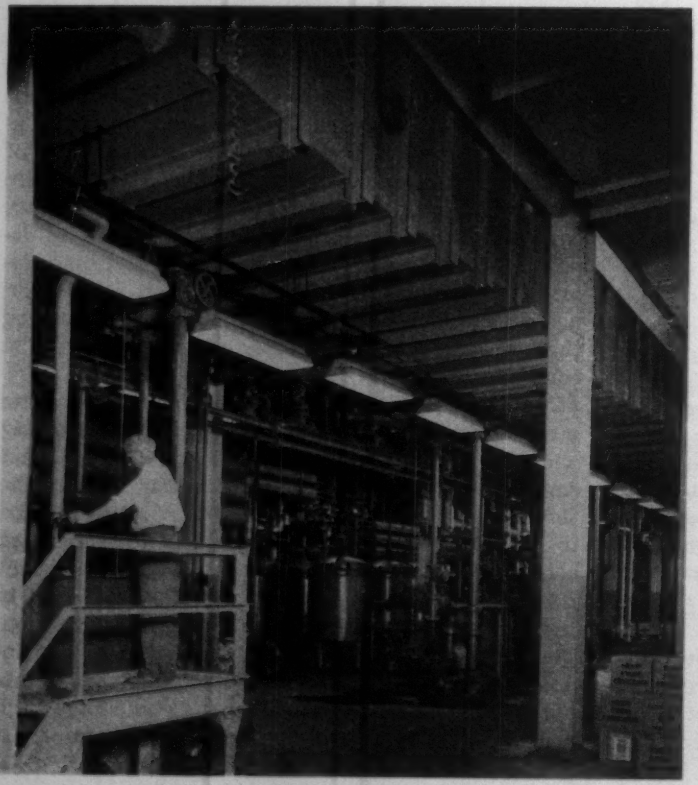
leads to the need for determining the most effective paperwork flow throughout the maintenance organization. This communication aspect of systems design is important for proper functioning of any organization. In organizing the accumulation of data, interpretation and evaluation of data, and transmitting appropriate recommendations, it is worthwhile to consider the usage and applications of tabulating machines for obtaining better control. Care should be taken that the vital flow of information both up and down the line be uninhibited with unnecessary data which only increase cost and lower the prestige of the initiating department; useless communications introduce an element of confusion into any project. However, proper systems design is invaluable for obtaining the necessary administrative adjustments in cost control.

Management has had to adopt and integrate many different techniques in effectively organizing and controlling production and one of the main concerns of industrial engineering has been in the field of cost control and cost reduction as applied to the control of production. With an increasing use of automated equipment, it is apparent that future opportunities for cost reduction will exist in the sphere of maintenance rather than production. This fact, coupled with the importance of continuous operation of the automated equipment, points out the ultimate need of applying industrial engineering techniques to maintenance operations if the function is to be successfully controlled.

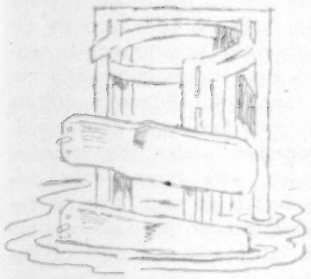


1 Plating installation at Chevrolet's spring and bumper plant in Livonia, Mich. System consists basically of three, straight line, fully automatic plating machines designed and built by the Meaker Co. of Chicago. Each machine is 17 feet wide, 25 feet high and 535 feet long. Installed side by side, each processes automobile bumpers through a complete copper, nickel and chromium plating sequence. Complete cycle consists of 41 precleaning, plating, reclaim and rinse operations. Any of the machines may be operated independently for a complete cycle.

AUTOMATION TODAY



2 An area of 180,000 square feet, on two floors, was required for the installation. A break with tradition was made when the plating machines and generators were put on the second floor and all process piping, filters, mixing tanks, heat exchangers and related components were located directly below on the first floor. This enables the system to be open and accessible without pits or trenches. Each tank extends but thirty inches above the second floor level, with the balance projecting below. 430,500 gallons of copper, nickel and chrome solutions are continuously filtered and circulated through this system.



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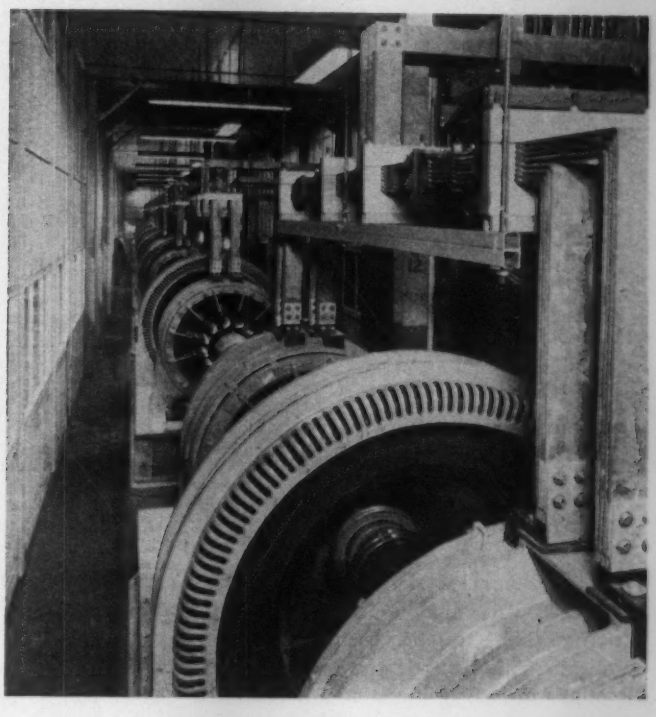


Direct current, low voltage power for plating processes is supplied by 48 motor-generator sets built by the Chandeysson Electric Co. of St. Louis. These sets range in size from 7500 amperes at 9 volts to 20,000 amperes at 12 volts. Total dc output of the generators is 652,000 amperes. Over a half million pounds of copper buss bar connect the generators with the tanks.

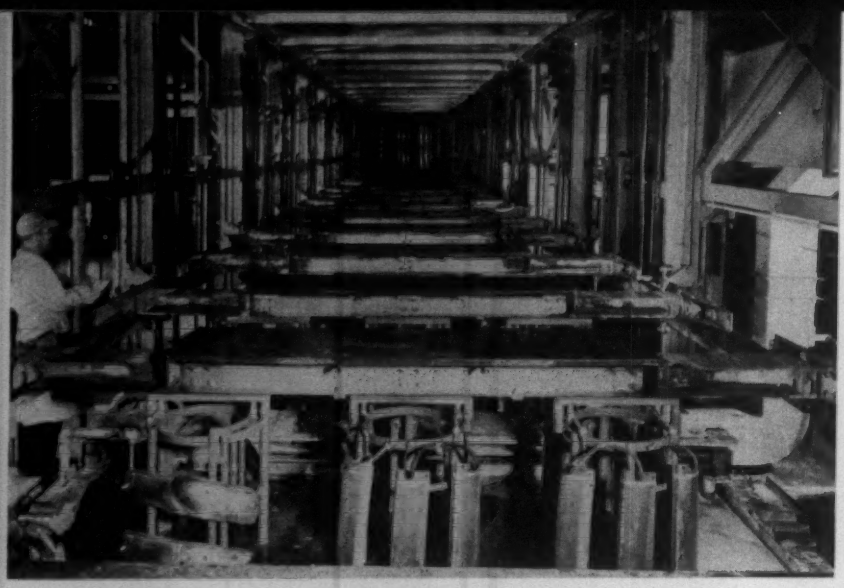
AUTOMATIC PLATING OF BUMPERS

A GIANT BY ANY MEASURE, is the phrase used to describe the plating facility engineered and installed by the George L. Nankervis Co. at the Livonia, Mich. spring and bumper plant of the Chevrolet Division of General Motors Corp. The third of a mile of plating machines require 906,000 gallons of solution—equivalent of 109 tank cars—to fill the 149 tanks. It is so big that the steel used in the machines alone would be enough to erect an ordinary 38 story office building. Electrical power consumed could illuminate 20,000 homes, but is used instead to plate over 19,000 automobile bumpers a day.

Each of three selective batch type plating machines performs a complete cycle of precleaning, plating, reclaim and rinse operations that applies copper, nickel and chromium to the bumpers.

Instead of the bumpers parading through the machine "follow-the-leader" style as they do in conventional straight-line machines, they actually pass each other "leap frog" style. This is the essence of batch type operation and is required because of the shape of the Chevrolet wrap-around bumper. To enable an even plate to be deposited on the curved surfaces, it is necessary to surround the bumpers with equally spaced or conforming anodes. This precludes any horizontal travel in the tanks. All horizonal travel must be *above* the tanks, and as the time intervals in the various processes differ so widely (rinse 57 seconds, copper plate 25 minutes), it is necessary for carriers loaded with racks of bumpers to pass each other in certain sections of the machine.

A shuttle, with a series of equally spaced pusher dogs, advances a loaded carrier directly over tank number 1 where it latches into place. Then the rails lower, immersing the bumpers. The shuttle returns to be in position for the next carrier. The bumpers remain in the first tank 57 seconds. During this time another load of bumpers is racked and lifted, ready to enter the machine on the next cycle. At the end of the 57-second interval, the bumpers are lifted out of tank number 1 and engaged with the shuttle again. This time the shuttle advances the carrier to tank number 2 and simultaneously pulls a new load off the elevator and



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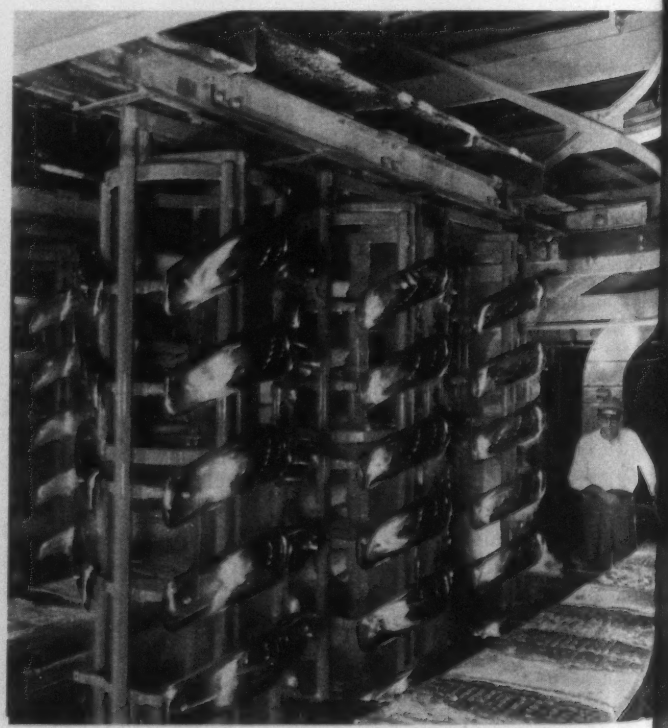
Shown here are the 15 precleaning tanks prior to copper. Every 107 seconds all the carriers pictured lift simultaneously, advance one tank and lower—immersing the bumpers into solution. Bumpers consist of a center bar and two wing ends which are bolted together under the bumper guards. Carriers with three racks are loaded on the first floor and lifted to the second floor plating area on a screw type elevator which is an integral part of the machine. When the carrier reaches the top of the elevator it is in alignment with the machine rails onto which it is rolled by means of an overhead shuttle system.

over tank number 1. The rails lower again immersing both racks. Raising, lowering and advancing the bumpers for each process takes 50 seconds. This period plus the 57 second dwell time gives an operating cycle of 107 seconds. After the bumpers have gone through a series of fifteen precleaning processes in this manner, they enter the copper section of the machine.

In the copper section, the carriers are advanced by a walking beam shuttle. As a load of bumpers leaves the precleaning section, it is advanced to a position directly above the first copper plating tank. Again a section of the rail, the width of the carrier, lowers — immersing the bumpers. An auxiliary rail immediately comes into position to replace the movable section, allowing subsequent carriers to roll past the filled tank. Each load of bumpers remains in the copper solution twenty-five minutes. Therefore, when the next carrier enters the copper section, 107 seconds later, it passes over the first copper tank and enters the second. This continues in sequence until all fifteen copper cells are filled. By the time the last one is filled, the first batch of bumpers is ready to be removed and advanced to the following reclaim and rinse tanks. Therefore, it is lifted out and advanced by the shuttle over fourteen copper cells and into the first reclaim rinse tank.

Immediately following copper plating, the bumpers are processed through a reclaim tank. Here the copper solution is washed off, preventing it from contaminating successive baths and trapping it for reclamation. Each week the contents of the reclaim tank are drained to a "dummy" or copper plateout tank where the copper is plated out of solution onto anodes. Scrap recovery of almost 500 pounds of pure electrolytic copper a week is realized.

Next the bumpers enter the nickel section. Here they remain in solution for twenty minutes to receive a 0.00075-inch deposit. In one of twelve tanks, holding a total of 166,200 gallons, each rack is immersed for 20 minutes. Here too, the solutions are continuously filtered and circulated through pure nickel heat exchangers to maintain an even temperature of 135F. As the bumpers



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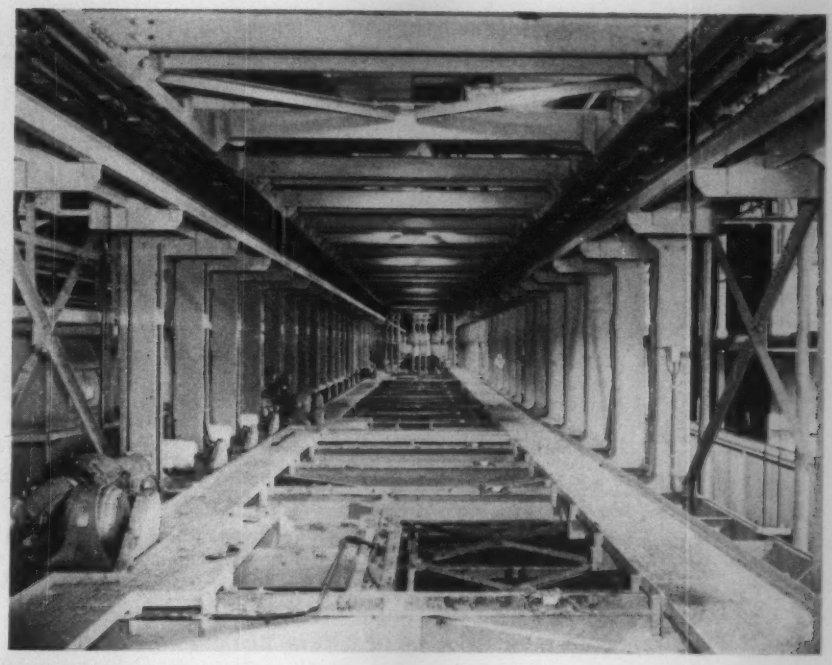
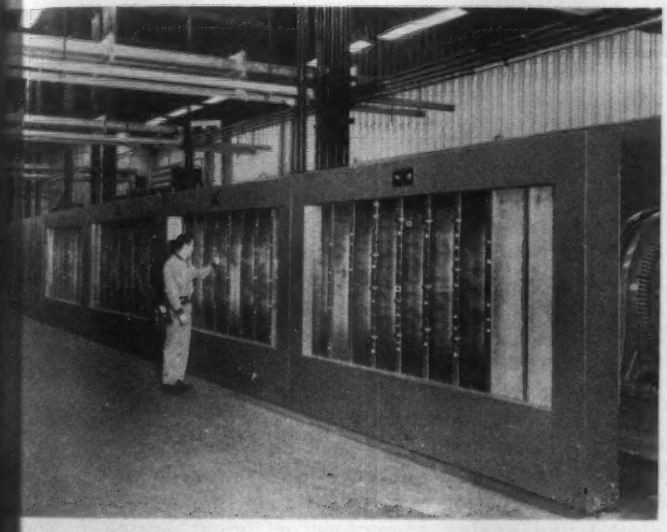
Bumpers are emerging from hot water rinse. Plating racks are designed to accommodate either 12 wing ends or 12 center bars. While in the acid copper tanks, the bumpers are surrounded by copper anodes which are positioned to conform to the shape of the bumpers. This nesting assures an even 0.0011 deposition on both the flat and the curved surfaces, and requires batch-type handling rather than continuous motion through the tank. This automated plating plant was engineered and installed by the George L. Nankervis Co. of Detroit.

6

When the finished bumpers are removed, the empty racks are lifted on chain elevators to the upper portion of the machine for rapid transit, by means of shuttles, back to the loading end of the machine. All the sequencing, selecting and indexing operations are completely automatic —being done with relays, limit switches, counters, timers and similar components. In preparation for weekends, the machines are run with the control set at *Storage* which causes the empty racks to be retained in this area above the machine and allows free access for inspection and maintenance of the rest of the machine.





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Installed as a part of the control system are W. F. & John Barnes Co. Electro-Graphic Detector Panels for maintenance purposes. These show the complete electrical system in schematic diagram—with wired-in checking circuits. Each point on the schematic which represents a contact, such as a limit switch, contactor, or timer, is actually wired to that particular component, either on the machines or in the control panels. Therefore, when it is necessary to check a component or circuit, an electrician simply locates the component on the Electro-Graphic Panel, and using a test probe, checks the circuit for correct operation. This eliminates the necessity of going directly to the components for testing and makes possible the checking of the machines with the power on. Over 710 miles of wire were used in the installation of the control and checking circuits.

leave the nickel section they are immersed into a reclaim tank and several water rinses.

With the completion of the nickel operations, the bumpers are again lowered on elevators to the first floor for buffing. Returning they enter the chrome section of the machine. Here, in one of three tanks, each holding 17,600 gallons of chromic acid, the final plate is deposited. A relatively quick process, it takes only four minutes to produce the gleaming, lustrous chrome finish. In spite of the seeming simplicity of the operation, the use of chromic acid requires special care. Each tank is lined with vinyl plastic to withstand the particularly oxidizing effect of the acid. And to protect the plastic from mechanical damage, each tank is brick lined. A high velocity exhaust system is used to remove the irritating acid fumes. Before exhausting the fumes they are thoroughly washed to remove all the chromic acid, thus preventing any staining "fall-out".

Following chorme plating, the bumpers enter a reclaim tank and several water rinses. They are then removed from the racks and loaded onto conveyors for delivery to the Shipping Department. Recovery of the chromic acid from the reclaim tank is accomplished through a distillation system. This not only contributes to economical operation as the acid is reused, but prevents it from being dumped into the sewer system for eventual pollution of public waters.

The engineering effort required to handle such a large assignment was accomplished on a team basis by groups of engineers, each specializing in a separate phase of the job; electrical, chemical, mechanical, civil, process piping, structural and other services. Additional details of the operations involved are shown in the accompanying illustrations.

This article is developed around the theme that the future evolution of automation will be along practical lines as evidenced by present trends. In the foreseeable future, centralized direction of a plant's production equipment by giant computing machines might conceivably be possible in some cases, but this cannot be expected to meet the test of practicability

A CAVEAT ON COMPUTERS

By **E. W. LEAVER** and **J. J. BROWN**

President
Electronic Associates Ltd.
Toronto, Canada

Staff Member
Aluminum Limited Group Co.
Montreal, Canada

MAN, even with all his adaptability and marvelous sensitivity to outside impressions, has been found wanting when it comes to operating today's highly complex industrial processes. And because men simply aren't up to the job, the trend in the last few years has been to introduce more automatic equipment. This is a sound move and one which will lead in time to higher levels of productivity and better design. There is, however, an urgent need for a critical appraisal of the role of the automatic computer in achieving these desirable goals in view of some of the unique theories and misconceptions regarding "giant brains" which have become so popular.

The current loose talk about computers running entire industrial processes runs counter to everything we know about both computers and machines. Functionally, man is the best computer ever created, and a measure of the human brain's superiority as a computer over the best electronic "brain" known today is in the number of its nerve cells. In the human brain, these run into the billions; the best computers have only a few thousand. Since the best computer of all, the human brain, is not good enough to do the job, it seems strange to hear the suggestion that we should replace it with a fantastically expensive computer, the height of whose accomplishment is to count on its fingers like an idiot child. Turing[1] and Sherrington[2] have ably outlined the essential differences between human brains and computers.

People working in the field of automatism believe that almost any industrial or commercial process could be made automatic if the economic pressures making for automatism were sufficiently strong. This argument seems to be supported by the history of automatism up to the present time. Where ultimate compulsions exist, such as in defense and warfare, automatism has had its most general application. When we need a gun laying machine which will help in shooting down enemy bombers, we tend to care less about how much the machine costs.

Working from this type of argument, some prognosticators have come up with the proposition that within a short time there will be a second industrial revolution, "the cybernetic revolution" caused by the introduction of automatic controls based on digital and analog computers or "giant brains."[3] For our part, we feel that this view is unrealistic and unwarranted, since we know from sad experience that industry is not waiting with open arms to receive devices of this kind. This is not to say that the "giant brains" method of solving industrial problems is not *possible*. Our claim is that it is not *practical*. It must be realized that there are extremely serious difficulties to be overcome before automatism, even properly applied, can be introduced to any great extent into our conventional production and distribution systems, let alone the dubious extrapolation of overall computer control.

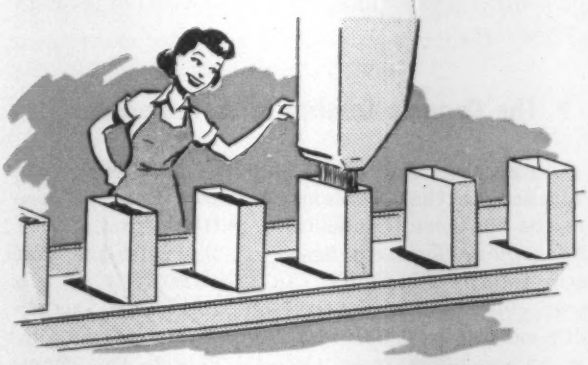
Error-actuated controls go back some 200 years, and even so complex an automatic machine as the automatic pilot for aircraft is nearly a quarter of a century old. Since the recent wars, literally thousands of engineers thoroughly familiar with all aspects of gun laying mechanisms have been working in British and American industries. Undoubtedly they have been trying hard to extend the scope and use of position controls to their

[1]References are tabulated at end of article.

branch of industry. But progress has been slow because of many difficulties such as the inflexibility of industrial techniques, the rigidity of our present concepts of machine and product design, and (principally) the sheer mental inertia of men.

▶ Role of the Computer

When the smoke raised by the spectacular fireworks of the "giant brain" advocates has cleared away, we think people are going to be appalled at how little solid fact is left. People may never become aware of this slight residue, however, because already these advocates have performed the semantic switch of calling every electronic or mechanical gadget (no matter how old) a "computer." This approach takes advantage of the widespread ignorance of a new field. If most electronic automata are called computers, even if the original meaning of the word "computer" is quite different,



The information needed on the production floor for the automatic control of machines is usually so simple that no computer is required, or so complex that even a computer is lost

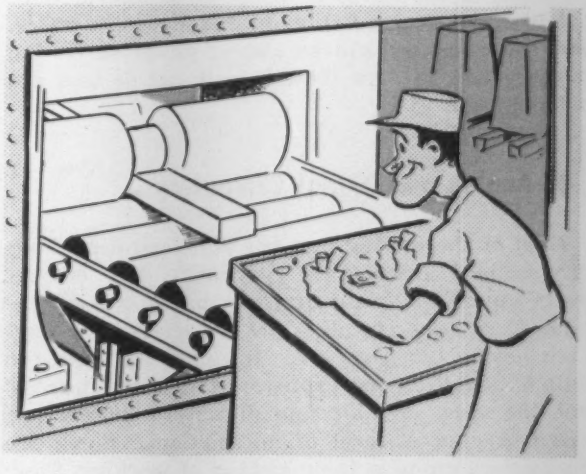
why then of course "computers" in this sense will be very widely used.

The function of a true computer is to compute. Computers have been successfully applied to research problems. They will continue to be so used and no doubt on an increasingly expanding scale. Stress analysis in aeronautical engineering, for example, is full of tedious computations, hence is an ideal field for the use of computers. But a computer doesn't generate information; it merely manipulates it. Moreover, the people feeding information into the computer aren't always wise either, and make mistakes.

We think it highly unlikely that large-scale computers of the type used in research can be used in production processing. Conditions in a manufacturing plant are different from those of the research laboratory. The information needed on the production floor for the automatic control of machines is usually so simple that no computer is required, or so complex that even a computer is lost. The fact of the matter is that the large digital computers are not *practical* for replacing human workers in industry. They are incapable of doing what must be done.

Some sort of case can be made for the argument that computers will find a place in the mass production processing of information. But here again we feel that the validity of the argument depends to a large extent on too wide a definition of the word "computer." Anyone reading "Electronics in the Modern Office" by Ralph W. Fairbanks will agree with us that computers, as such, are hardly capable of running everything in the business office.[4] It should be remembered that for most business applications the machine has to compete, not with the most brilliant graduate of the Harvard Business School, but only with a clerk who left school at age 16 and went to work.

The first and most obvious field for automatism in business is the replacement of clerks in the high-volume, low-profit per unit type of business such as a mail order house. Simple electronic machines will probably be used similar to one that utilizes the selective sequence principle, i.e., flipping rapidly through a list of all possible cases until it comes to the case that fits. It is not correct to call such



machines as these "computers," because they don't compute. We call them electronic automata if they work without any human aid, or electronic units if they require some help from human beings.

A second large field for automatism in business is in the life insurance industry, where hordes of clerks do exactly the same work day after day. The information they handle can just as well be handled by relatively simple electronic automata, if we go to the electronic methods of storing the business information.

Since the role of the computer is computation, and not much real computation is required in the average business, we feel that computers as such have been much overplayed. On the other hand, several companies are now doing payroll and in-

The authors of this article recognize the existence of a semantic problem in discussing computers and in interpreting articles about computers. As an idea of the size of the semantic problem, consider the confusion which would result if the word "transporter" were used to describe everything from a kiddie car to a rocket ship. The practical aspects of the problem are further complicated by visionaries (both scientific and pseudoscientific) and their camp followers who insist upon weaving the pattern of their dream of "giant brains" around the decidedly useful but immature products of a relatively young industry. For the purposes of this article, the authors define a computer as a large agglomeration of electronic hardware that has been properly taped with a machine's eye view by hopeful and persistent mathematicians for the solution of miscellaneous problems (chiefly mathematical).

ventory work by means of electronic machines which are, at least in part, computers. In work of this kind some actual computation is required.

To summarize then, since the computer is built for calculating, its chief area of usefulness will be research, and it will have some use in information-handling and computation in the business office. But the computer will be almost unknown on the factory floor because the things it can do best are not required.

Analog and Digital Computers

Most of the writing that has appeared describing programmed calculators (popularly but erroneously known as "giant brains") has stated or implied that these machines are automata at a very high level. When we come to apply the tests for automatism it becomes apparent that this is usually not the case. Analog and digital computers are often the lowest level of automatism. Some are really very crude in their *method* of working. They are remarkable chiefly because of their speed of iteration (doing the same thing over and over again). The fact that such machines as ENIAC, BINAC, and SEAC, use information as their raw material rather than goods has tended to confuse our thinking about them. But information is a raw material just like any other, and the control methods used in processing it can be compared, for instance, to those used in processing ores.

The latest types of electronic calculators have moved some way up the scale. FOSDIC, UNIVAC, EDSAC, and NORC, for example, exhibit a slightly higher degree of automatism because they are capable of changing their program part way through the calculating run. They are still intermittent-programmed computers, but they have the added ability to compare results at any stage of the process with fixed standards, and to take further action depending on the results of collation at this point. All calculating machines so far announced perform a more or less fixed set of operations on information, and require a human operator to take appropriate action as the result of the new information they produce.

Popular literature now has such units controlling an entire factory. But we cannot agree that even the most advanced computer is suitable for this role. In our opinion, central control of process detailing is inferior to local control (given the present state of the electronic art) and will remain so for many years to come.

We believe that the chance of a computer running a factory remains in the field of fiction rather than fact, yet we must admit that we are partly to blame for the "giant brain" mania that is sweeping the country. Our 1946 article in *Fortune* spoke of the "brains and nervous system" of the factory, and sowed a form of central control. For this, we apologize. But in partial extenuation, it should be noted that there is a difference in kind between the central record racks we suggested (just to have all the records handy in one place) and central control of *every* machine action through a *computer*.

The Organic Quality of Automatism

There are two fundamentally different approaches to the problem of automatism. These are the *synthetic* (imposing a pattern from above) and *organic* (growth based on the principle that form follows function). In the first you have a large collection of controllable units in a factory with central collation and control *imposed* on this set of machines from above. This is the "computer" approach. *The units are not automata at all*, and the system as a whole brings automatism into play at only a relatively high level. In organizations of this sort you need a digital computer at the top to control every detail of the program, and to take care of any operational troubles that may develop in any of the machines for any reason. Here the control problems are immense, the difficulties being implicit in the type of organization.

The second kind of organization is to have *automatic* machines at the very simplest level. The automata are integrated into a system in which there is feedback *within* the individual machines, and also *between* the various units making up the system.

The radical difference between these two approaches to automatism may perhaps be clarified by considering the following biological analogy. The daily work of the human body is carried forward by two kinds of organization, those falling under the control of the will, and those carried on automatically. Man is provided with a built-in thinking machine, yet in terms of energy, most of the work carried on by the individual (breathing, circulation of blood) is carried on automatically day and night without the intervention of the "thinking" part of the human brain at all. The

heart, for example, is operated by the so-called "pacemaker," which goes on without our having to think about it.

Biologically, it has been found economical to use this type of organization in combining the various units of the body into a man. Units, such as the heart, are automata, carrying out their functions without "detailing" from the "thinking" area of the brain. We believe that the same general laws of organization apply in the introduction of automatism to industry. That is, the individual machines themselves should be made as automatic as possible, and they should then be co-ordinated directly with each other without unnecessary interference from control or "brain" mechanisms at a higher level.

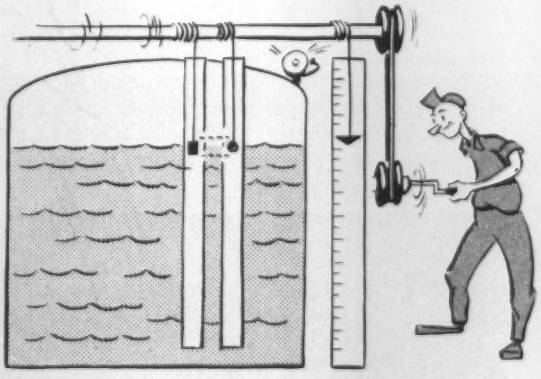
A flower or any other organic substance is built from the ground up. The pattern which determines what shape and color the grown flower will have is locked within the seed. These patterns are not superimposed on the growing plant from without. In precisely the same way, automatism will be an *organic* growth from the present factory system. The truly automatic factory will grow out of today's factory. This means that there will be no question at any time of superimposing machines on the factory telling it how to "think."

Since the role of the computer is an important question, it might be wise to look at the present status of electronics in industrial processes, to see in what direction and at what speed electronics is moving, and to make some prediction as to how soon it will reach the higher stages of automatism.

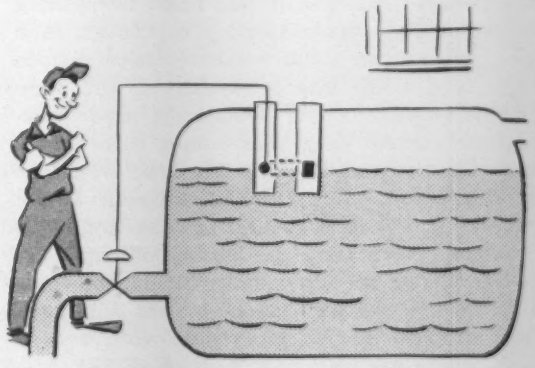
The two points of view in question can best be illustrated by taking a specific example. Say you have a piece of steel sheet that has to be put through a rolling mill to make it thinner. There are two ways of doing this. The first is to measure the thickness of the steel just as it leaves the rolls of the mill. The output of this measuring unit can be made to control the pressure on the rolls such that when the sheet is too thick, the pressure increases and when the sheet is too thin, the pressure decreases. This is a simple and practical application of an electronic unit to control a production machine.

The second way this job could be done it to feed information about the finished thickness desired into a digital or other type of computer. Then the computer is fed with other data of all kinds taken from reference books. The data will comprise all that is known about the properties of this particular sheet and the characteristics of this particular rolling mill. Once the computer has been given

Evolution and Electronics



The stages of growth of electronics in industrial applications are illustrated by these two examples. The first stage is merely a problem in measurement, in this case involving liquid chlorine in a tank. Liquid chlorine is dangerous and very cold, and the gas above the liquid is corrosive—both factors rule out the use of conventional measuring devices. The problem was solved by installing two wells in the tank—one well containing radium, and the other a Geiger tube. The two are mechanically linked so they can be raised and lowered together. The number of electrical pulses per unit time from the Geiger tube falls when the liquid is entered, because of the higher absorption of gamma rays by the liquid as compared with the gas. The operator simply turns a crank which lowers the two containers, a bell rings when the surface of the liquid chlorine is entered, and the operator reads the scale.



The second stage of progress is reached when the measuring instrument is linked directly to a control which does not require the use of a human operator. As an example, in an ammonia plant, a receiver is operated at a pressure of close to 10,000 psi, a pressure which prohibits readings by conventional measuring instruments. A valve (formerly operated by a man) controls the inflow of the raw material to the receiver. If the inflow were too slow, production was low. If it were allowed to get too high, the material overflowed into the catalyst and production stopped. The problem involves both measurement and control. To solve this problem two wells were installed in the receiver, one containing a radioactive material and the other a Geiger tube. The output of the Geiger tube is fed into a controller which activates the valve, thus automatically keeping the material at the proper level.

all the information or "taped," it is started, and after considerable high-speed calculation it tells you how much pressure to put on the rolls of the mill. If all the data fed into the computer were accurate and obtainable, this second method might work.

There is an essential difference in *kind* between these two approaches. The first is a logical extension of electronic equipment actually in use in factories today, and could be presented seriously in a technical journal. The second is best suited to the fantastic-fiction type of writing.

We believe that electronics will some day make possible complete automatism—the overall automatic control of all aspects of the production process. But this is very different from anything we have in industry today, and will not come soon. It is not without significance that those who claim that the development of electronics in industry is going to run to giant computers come, for the most part, from outside industry. It is unfortunate that the journalists who have taken up these notions and reworked them for popular consumption have gone overboard on computers. Any machine that uses electronics to pull the plug out of a beer barrel is to them the latest triumph of scientific ingenuity—another "giant brain."

The best reason for believing that computers are never likely to play a very important part in the production of goods is simply that they are not needed. In the ordinary factory, there will hardly be a production job that a computer can do in the practical sense.

It is probably true that if you knew everything that determines the properties for a product, such as paper, and if you could measure these factors and then feed them into a computer, the computer would be able to feed back to the paper making machine control data that would make paper of the quality required. This machine would be a true automaton. But this development is not a possibility in the near future, because not all of the variables determining the quality of paper are known today, nor are they likely to be known in the near future. In any machine it is axiomatic that the simplest usable method is always best. Although electronic methods are often the only practical way, only sometimes are they also simpler.

Automatism can be expected to grow up in industry in stages—progressing from simple local applications of electronic instrumentation to electronic control devices, which, when broadly applied and co-ordinated, will provide the needed basis for automatism. Actual applications of this kind, carefully engineered and solidly based on industry's actual need, show the practical way toward automatism.

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Courtesy Mattison Machine Works

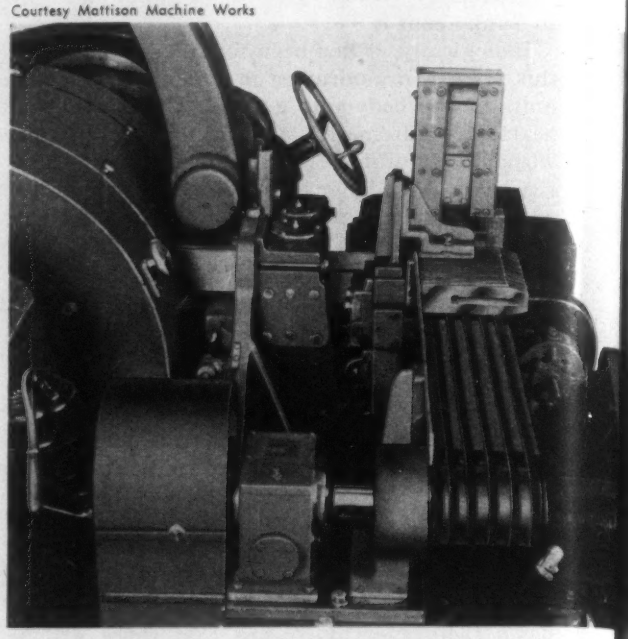
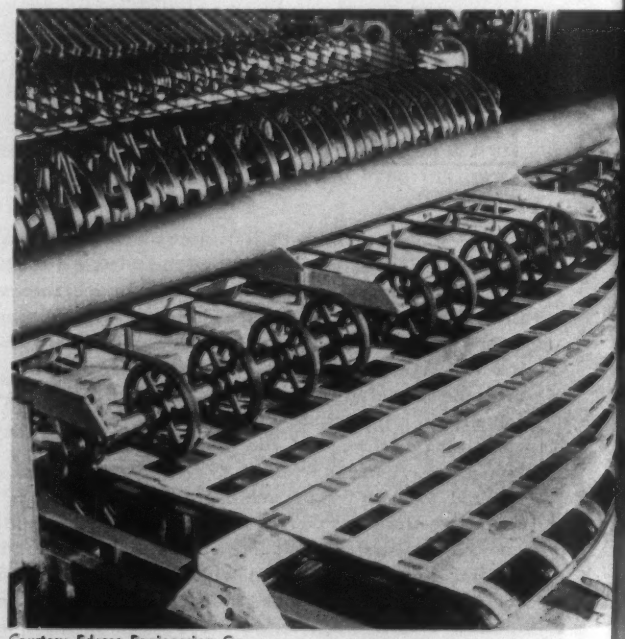


Fig. 1—Feeding carpenters'-plane blades to double disk grinding machine. V-belts carry the blades held on edge to a magazine in the rear, where they are fed by flat belt between rubber rolls. With this arrangement 1000 blades per hour are processed

Fig. 2—Infeed of the infrared drying and gluing machine. Strips of veneer with edges spread with glue are approaching the crowding device



Courtesy Ederer Engineering Co.

V-BELTS IN THE CONVEYOR FAMILY

APPLICATIONS which come to mind when thinking of V-belts usually fall into the category of power transmission. However, in the automation field, V-belts are being used also as feeding and conveying devices—and with notable success.

A manufacturer of double disk grinders, Mattison Machine Works of Rockford, Ill., has made use of a gang of uniformly-spaced V-belts running in parallel for delivering carpenters'-plane blades into a magazine, *Fig.* 1. A flat belt then carries them from the magazine to rubber rolls which "walk" the blades between the grinding disks. This is typical of high-production jobs possible when automated methods of feeding are developed to more fully utilize machine productive capacity.

Courtesy Gates Rubber Co.

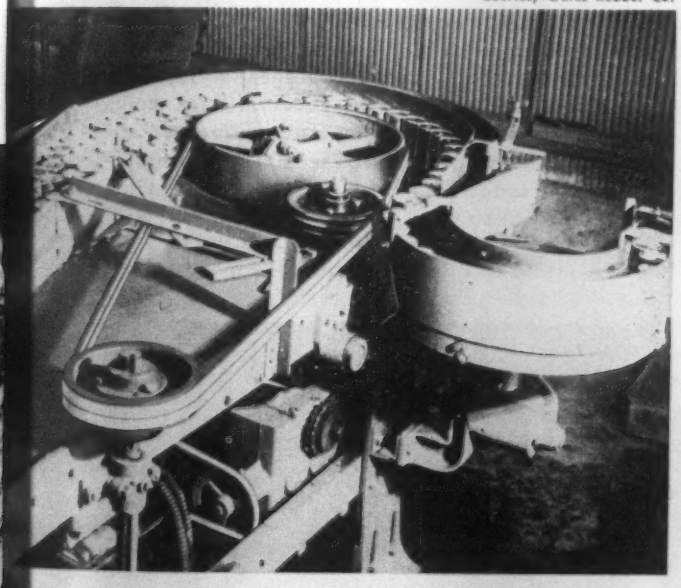


Fig. 3—Converging table in the canning plant of Rochelle Asparagus Co. where the V-belt contact device serves to gently rotate the cans and keep them moving smoothly around the curve to a point where they proceed single file. Note the grooved idler which contacts and rotates the cans at the point where they enter the labeling machine conveyor

V-belts function to provide joining and clamping in a device on an infrared glue-drying machine, *Fig.* 2. In this case, after veneer strips have glue spread on their edges, they are placed on a series of flat belts which carry them into the machine in relatively uniform lateral spacing. The gang of flat belts moves veneer strips under a gang of V-belts mounted on a common shaft overhanging the flat-belt conveyor. The arrangement is such that the V-belt crowding device overruns the flat belt conveyor in linear speed by a considerable amount. In consequence, friction of the V-belts on the strips of veneer is sufficient to push the glued edges firmly together as they continue their travel through the machine. The now continuous sheet of veneer passes infrared heating units which quickly cure the resin glue.

Ordinarily, V-belts mounted on sheaves with their axes vertical have little relationship to conveyor service. An exception is found at the canning plant of Rochelle Asparagus Co. where the output of several canning machines is passed through a single labeling machine. Several streams of cans must be combined into one—all the cans are passed across a so-called converging table.

Cans formerly were pushed onto this converging table by their respective conveyors, then into the labeling machine after being unscrambled. Sometimes the cans became locked or jammed on the converging table. The general superintendent of the plant felt that if the cans could be rotated, they would unscramble more readily. Accordingly, the Gates Rubber Co. of Denver worked out an arrangement whereby a large flat pulley, driven by V-belts from a vertical shaft, was installed in the center of the converging table, *Fig.* 3. The cans come into contact with the slowly-moving V-belts, and are gently rotated. Rolling against one another prevents cans from jamming as they progress toward the line leading into the labeling machine. A grooved idler at the beginning of the labeling-machine conveyor moves the cans smoothly past this point.

While a far greater portion of V-belt applications are and probably always will be of the power transmission variety, conveyor applications promise to develop into an economical and versatile addition to the materials handling area of automation.

INSPECTING AND TESTING MAGNETS

MECHANICAL INSPECTION and magnetic testing operations in production of speaker magnets are combined in two compact machines installed by Carboloy Dept. of General Electric Co. Speaker magnet production in the plant has tripled; these units were designed to inspect the increased volume of production to see that magnets shipped are well within the range of industry standards.

Two operators by use of these machines, *Fig.* 1, can handle the checking of specified mechanical and magnetic properties of the speaker magnets produced. Each machine is a separate unit, operates independently of the other, and performs different functions. Parts are fed to each unit from a bin at the left of that unit. A cleated belt conveyor carries the pieces from the bin up a 60-degree incline and drops them into a rotating hopper. A time delay type switch in the hopper controls the elevator conveyor. While the hopper is sufficiently loaded with stock, the switch is steadily held open by the tumbling parts in the hopper, and the elevator remains at rest. When the number of pieces in the hopper gets low, the switch closes and the elevator belt runs until enough parts are in the hopper to hold the switch open again.

The mechanical inspection unit, *Fig.* 2, processes 2100 pieces per hour. Parts fed from the hopper are automatically positioned and roll down a gravity conveyor for visual inspection. Defective parts detected visually are removed from the conveyor by the operator. Parts passed by the operator are automatically checked for length, outside diameter, end-squareness, and parallelism at separate stations. Tolerances held on length and diameter are plus or minus 0.001-inch and maximum 0.002-inch on end-squareness. A workpiece measuring outside these limits is automatically dropped out of the line by a solenoid-controlled gate at the station where it fails to pass. Rejects are thus segregated into classes of defective pieces, and separate counts are kept on the number of pieces falling in each class. Parts passing these mechanical checks satisfactorily are dropped into boxes for storage and handling.

Parts are fed from the hopper of the magnetic tester, at right in *Fig.* 1, down a gravity conveyor to a feed wheel. They are magnetized and then tested by comparing them with a standard magnet of a known energy level. The machine can be calibrated for various sizes of magnets and can check magnets in seven energy levels ranging from 3.5 to 6.5 megagauss-oersteds. After testing, the magnets are automatically segregated by energy levels and dropped into separate containers corresponding to their energy levels. About 1600 speaker magnets can be individually tested in this unit per hour.

Such inspection and testing units increase output per inspector, give accurate 100 per cent inspection, and reduce inspector fatigue—worthwhile goals in any industry.

Fig. 1—Two units shown here are used for mechanical inspection and magnetic testing of speaker magnets. Parts are visually inspected and dimensions automatically checked on machine at left. Energy level of the pieces is tested on the magnetic tester at right

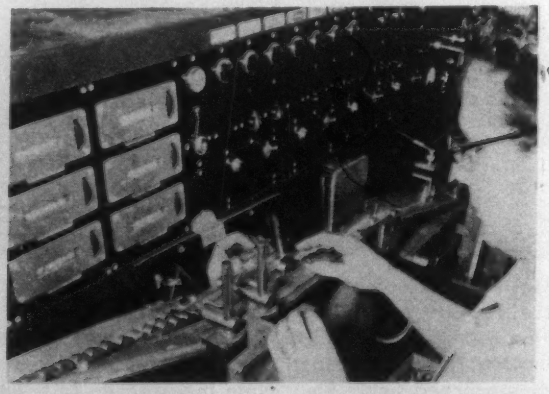


Fig. 2—Close-up of the mechanical inspection unit shows the visual inspection station. Counters separately record number of rejects in various classifications

We moderns are hearing about such things as *and*, *or* and *not* functions. These relationships are used in switching and relay circuits and in computer elements—or what some choose to call "electronic brains." But aren't these logic functions but a new twist to the deductive reasoning of Aristotle? Here we have a hint which explains the overwhelming and unapproached superiority of the human mind—inductive reasoning

HOW NUMERICAL CONTROL WORKS

By ROBERT W. BROOKS
Vice President
Computer Control Co. Inc.
Wellesley, Mass.

EXTREMELY COMPLEX manipulations and numerical computations can be built from a few simple operations. The basis for such operations is a form of symbolic logic which deals with the question of whether a certain relationship is true or false under a given set of conditions. These true and false alternatives are of great practical value since they can be represented conveniently by physical equipment—a light being on or off, a relay open or closed, a vacuum tube conducting or nonconducting, or a voltage pulse being present or absent. This type of instrumentation is ideal for computations with binary numbers, used so frequently in automation for numerical control and computer operations.

Logical relationships or statements are established by the use of three connectives—*and*, *or*, and *not*, represented symbolically in *Fig.* 1. *Not* represents negation, or opposition. For example, if condition *A* is true, then condition *not A* is false. The connective *and* may join two conditions to indicate that *A and B* is true only when both *A* and *B* are true. The connective *and* is thus restrictive in the sense that it requires that two conditions be simultaneously true. The connective *or* indicates that *A or B* is true whenever either *A* or *B* or both *A* and *B* are true. The connective *or* is less restrictive in that it can be true under three possible conditions.

Several graphical methods have been devised for representing logical relationship among variables. A simple tabular method employs 1 to indicate *true* and 0 to indicate *false*. For two variables *A* and *B* there are four possible conditions as shown in *Fig.* 2. The effect of the three connectives on the truth statements is also shown.

Four combinations of two variables can also be represented conveniently by combinations of squares, as in *Fig.* 3. The shaded squares indicate *true* and the unshaded squares indicate *false*. There are 16 possible combinations, or 2 raised to the power 2^n, with n being the number of variables.

All combinations of three variables *A*, *B*, and *C* can be represented on a logic chart having eight squares. The number of such possibilities is $2^8 = 256$. The method for building a simple logical

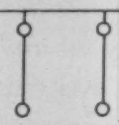
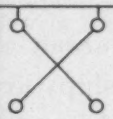
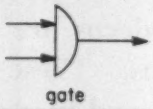
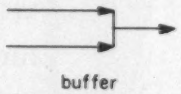
	True (assertion)	False, not (negation)	and	or
Written Symbol	A	$\bar{A}$	$(A \cdot B)$	$(A \vee B)$
Schematic Representation			 gate	 buffer
Common Equipment Forms	positive dc voltage (through feed) — pulse present	dc voltage polarity reversal — no pulse	coincidence detector	summing circuit and limiter

Fig. 1—Representation of conditions and connectives of symbolic logic. The three basic functions are *and*, or and *not* relationships

statement in three variables such as $(not\ A \cdot B) \vee (C)$, is shown in *Fig.* 4.

▶ Implementation with Equipment

To implement logical statements with physical equipment, it is necessary to have signals which represent the true and false conditions (for example, positive and negative voltages), and physical components which symbolize the three connectives defined in *Fig.* 1. The connective *not* is represented by a form of inverter which might, for example, produce a negative signal when it receives a positive one, or produce no pulse when it receives a pulse. Such a *not* component will produce *not A* when it receives *A*, or will produce *B* when it receives *not B*.

The *and* connective is represented by a gate shown symbolically in *Fig.* 1. Physically, the gate is a component which requires that all of its inputs be true in order that the output be true. If there is one false input, the output will be false.

The element which produces the *or* connective is called a buffer. In effect, the buffer is merely a direct connection between several variables so that if one or more of the variables is true, a truth will appear at the buffer output.

To represent any function of three variables, the combined gate and buffer instrumentation of *Fig.* 5 can be used. This consists of eight separate gates each having three input legs. Each of these gates corresponds to one of eight squares in the three-variable table of *Fig.* 4. The truth of a statement can be determined by implementing the truth, or shaded squares of the table.

Shown in *Fig.* 6, the four-gate 3C-PAC gating package of the Computer Control Co., can perform all of the functions possible with the eight-gate package of *Fig.* 5. In addition to being able to handle all functions of three variables, this arrangement can handle 51,358 functions of four variables and many functions of five or more variables. It can replace the eight-gate package because of inclusion of an inverter at the output. The output inverter permits either the truth or the false of the output to be selected as desired. The gates are used to represent either the shaded or the unshaded squares in the chart, whichever is the lesser in number. Four gates are the maximum number required, and many three-variable functions can be represented by using three or fewer gates.

The general rules for implementing any function of three variables with the arrangement of *Fig.* 6 are as follows:

1. Shade in the squares of the three-variable chart that represent the truth of the defined function f.

Four Basic Truth Conditions		not		and	or	not-and	not-or	(etc.)	
A	B	$\bar{A}$	$\bar{B}$	$(A \cdot B)$	$(A \vee B)$	$(\bar{A} \cdot \bar{B})$	$(\bar{A} \vee \bar{B})$	$(\bar{A} \cdot B)$	$(A \vee \bar{B})$
0	0	1	1	0	0	1	1	0	1
0	1	1	0	0	1	0	1	1	0
1	1	0	0	1	1	0	0	0	1
1	0	0	1	0	1	0	1	0	1

1 = true
0 = false

Fig. 2—Four basic conditions of two variables and effects of connectives *not*, *and*, *or*

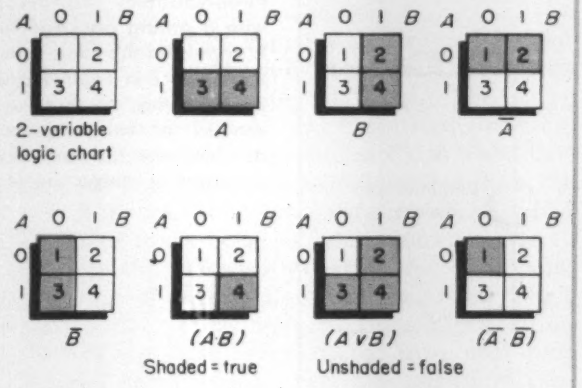


Fig. 3—Logic charts showing conditions of two variables. Note how the *and* function is restrictive and the *or* less so in forming relationships

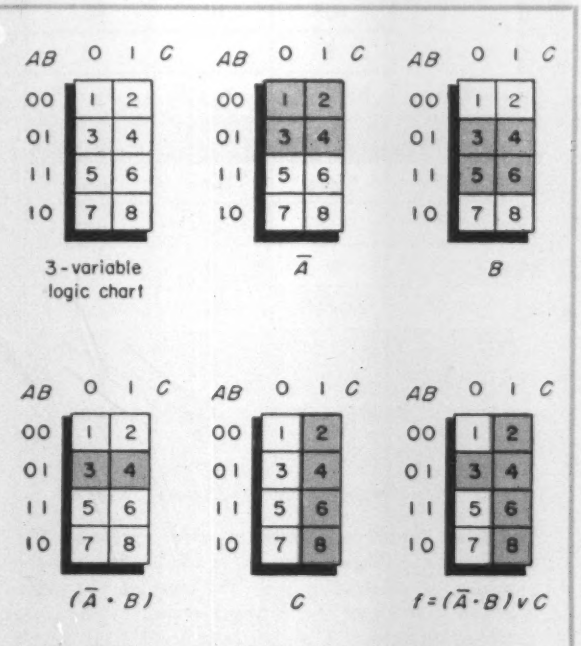


Fig. 4—Three-variable logic chart and construction of the function *(not A · B) v C*

2. If the number of shaded squares is four or less, implement the function *f* by making the connections that correspond to the shaded squares. The positive output lead indicates the *truth f* of the function represented; the negative output lead represents the *false f*.

3. If the number of shaded squares is greater than four, implement the function *f* by making the connections that correspond to the unshaded squares, i.e., implement the *false f* of the function. The negative output lead represents the *truth f* of the described function; the positive output lead represents the *false f* of the function.

The preceding discussion of symbolic logic has not been limited to any particular type of true or false signals. They could very well be dc voltage signals of positive or negative polarity to represent assertion or negation. Many logical manipulations and computations, however, must be performed at very high speed to be useful. The gating package of *Fig.* 6 has been designed to operate on pulses having a one-megacycle repetition rate. Truth, or assertion, is represented by the presence of a positive pulse on the assertion lead; false, or negation, is represented by the presence of a negative pulse on the negation lead.

In operation, synchronized pulse trains enter the gate legs, and pass through the gates and buffer to provide a resultant output pulse train. One such pulse operation is performed each microsecond. The result of this operation is carried over for use during the next pulse period. The one-pulse-period delay is used to perform this carry-over function, and aids in the synchronization of pulse signals. It will be shown later how the use of serial or parallel methods of instrumentation affect the time sequence of the different pulse operations. It should also be noted that accessory delay equipment is available for use when it is desired to hold an output pulse train for greater than one pulse period.

▶ Binary Arithmetic

In logical analyses, the pulse, no-pulse conditions handled by the gating package can serve to determine the true or false of complex logical

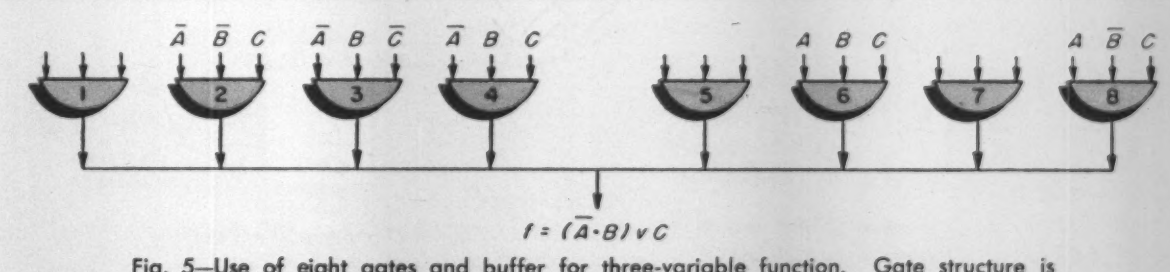


Fig. 5—Use of eight gates and buffer for three-variable function. Gate structure is shown set to represent the truth of the simple statement *(not A · B) v C* of *Fig.* 4. The false of a statement can be represented by merely implementing the unshaded squares of the logic chart

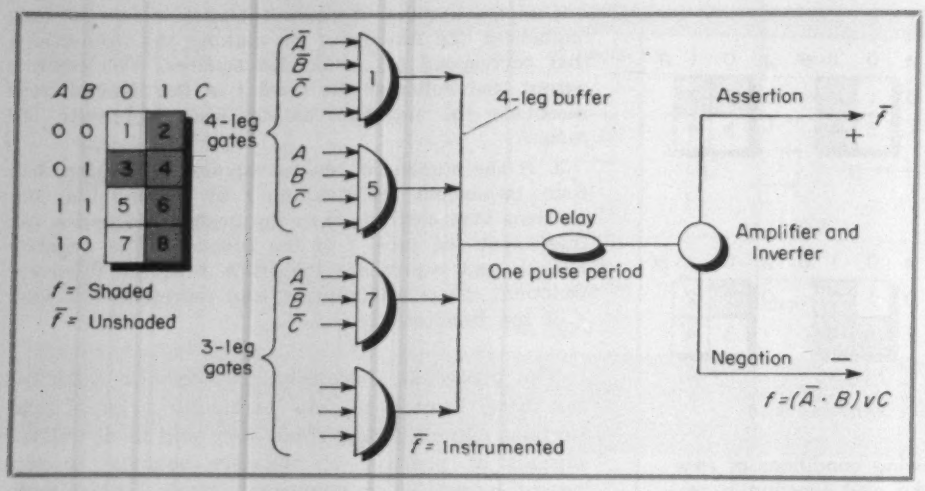


Fig. 6—Representation of three-variable function with a gating package set to represent the same function shown in *Figs.* 4 and 5. Note that the three unshaded or false squares are implemented and that a negative output results

reasoning. These two physical pulse, no-pulse conditions are also well suited to binary digital computation. Basis for both decimal and binary number systems are shown in *Fig.* 7. The decimal number system is built from powers of 10. The binary number system, consisting of only two digits 1 and 0, is built from powers of 2.

Binary addition and subtraction follow the simple rules set forth in *Fig.* 8. As might be expected, it is necessary to carry and borrow in binary addition and subtraction in essentially the same manner as in decimal addition and subtraction.

The most common method for performing binary addition is called the serial method. By this method, illustrated in *Fig.* 9, two binary numbers are added by commencing with the right-hand column and progressing to the left, carrying a 1 to the next higher column when a (1 + 1) addition is indicated. The two numbers *A* and *B* can be thought of as two pulse trains entering an adding network precisely at successive pulse periods. Using 3C-PACs, these two numbers "march" into the adder at the rate of one column per microsecond. As will be shown, the adding device must

DECIMAL

	Hundreds	Tens	Units
	10^2	10^1	10^0
	8	7	3
873 =	8×10^2 +	7×10^1	$+3\times10^0$

BINARY

	Eights	Fours	Twos	Units
	2^3	2^2	2^1	2^0
9=	1	0	0	1
9=	1×2^3	$+0\times2^2$	$+0\times2^1$	$+1\times2^0$

0	1	1	1	0	0 = 28
	1	(1x2)+1	(3x2)+1	(7x2)	(14x2)
	1	3	7	14	28
		Dabble	Dabble	Double	Double

Fig. 7—Decimal and binary number systems. The "double or dabble" method of evaluating binary numbers is illustrated with the number 011100. Starting with 1 at the highest order 1, the 1 is doubled to equal 2 if the next digit is a 0. If the next digit is a 1, the 1 is dabbled—doubled plus 1 to equal 3. This process is repeated with the accumulated total as shown

Addition Rules:

0	0	1	1	Carry 1
+0	+1	+0	+1	to next
0	1	1	10	higher column

Sample:

0111 = 0+4+2+1 = 7
0100 = 0+4+0+0 = +4
1011 = 8+0+2+1 = 11

Subtraction Rules:

0	1	1	0	And borrow
−0	−0	−1	−1	1 from next
0	1	0	1	higher column

Sample:

011101 = 0+16+8+4+0+1 = 29
010101 = 0−16−0−4−0−1 = 21
001000 = 0+0+8+0+0+0 = 8

Fig. 8—Addition and subtraction of binary numbers showing carry and borrow methods

merely be a digital network arranged to perform the addition as illustrated in *Fig.* 8.

A carrying circuit supplies a third pulse input *C*. The carry signals are fed back from the output through the one-pulse-period delay. The carry digit is thus added to the next higher-order column, and is indicated with a prime, as *C′*, to show that it is generated one pulse period earlier than the *A* and *B* inputs. How two digital numbers *A* and *B* are added in six pulse periods is shown in *Fig.* 9.

Defining the following variables, A = incoming binary digit of augend, B = incoming binary digit of addend, C′ = carry digit determined by addition performed one pulse period earlier, S = sum digit of column being added, then two logical expressions can be written to represent the carry and sum functions:

$$C = (\overline{A} \cdot B \cdot C') \vee (A \cdot \overline{B} \cdot C') \vee (A \cdot B \cdot \overline{C'}) \vee (A \cdot B \cdot C')$$

$$S = (A \cdot \overline{B} \cdot \overline{C'}) \vee (\overline{A} \cdot B \cdot \overline{C'}) \vee (\overline{A} \cdot \overline{B} \cdot C') \vee (A \cdot B \cdot C')$$

Set up in the form of logic charts, the carry and sum functions appear as shown in *Fig.* 10.

Serial method of addition requires as many pulse periods of time as there are columns of digits to be added. If a faster addition is required, the parallel method may be used. However, it requires as many sets of carry and sum 3C-PACs as there are columns to be added.

Binary subtraction by the serial method is performed as shown in *Fig.* 8. From the definitions, A = incoming binary digit of minuend, B = incoming binary digit of subtrahend, C′ = borrow digit determined by subtraction of preceding column, D = difference digit of column being subtracted, the following logical expressions for the borrow and difference functions can be written

$$C = (\overline{A} \cdot \overline{B} \cdot C') \vee (\overline{A} \cdot B \cdot \overline{C'}) \vee (\overline{A} \cdot B \cdot C') \vee (A \cdot B \cdot C')$$

$$D = (A \cdot \overline{B} \cdot \overline{C'}) \vee (\overline{A} \cdot B \cdot \overline{C'}) \vee (\overline{A} \cdot \overline{B} \cdot C') \vee (A \cdot B \cdot C')$$

Logic charts for the serial method of binary

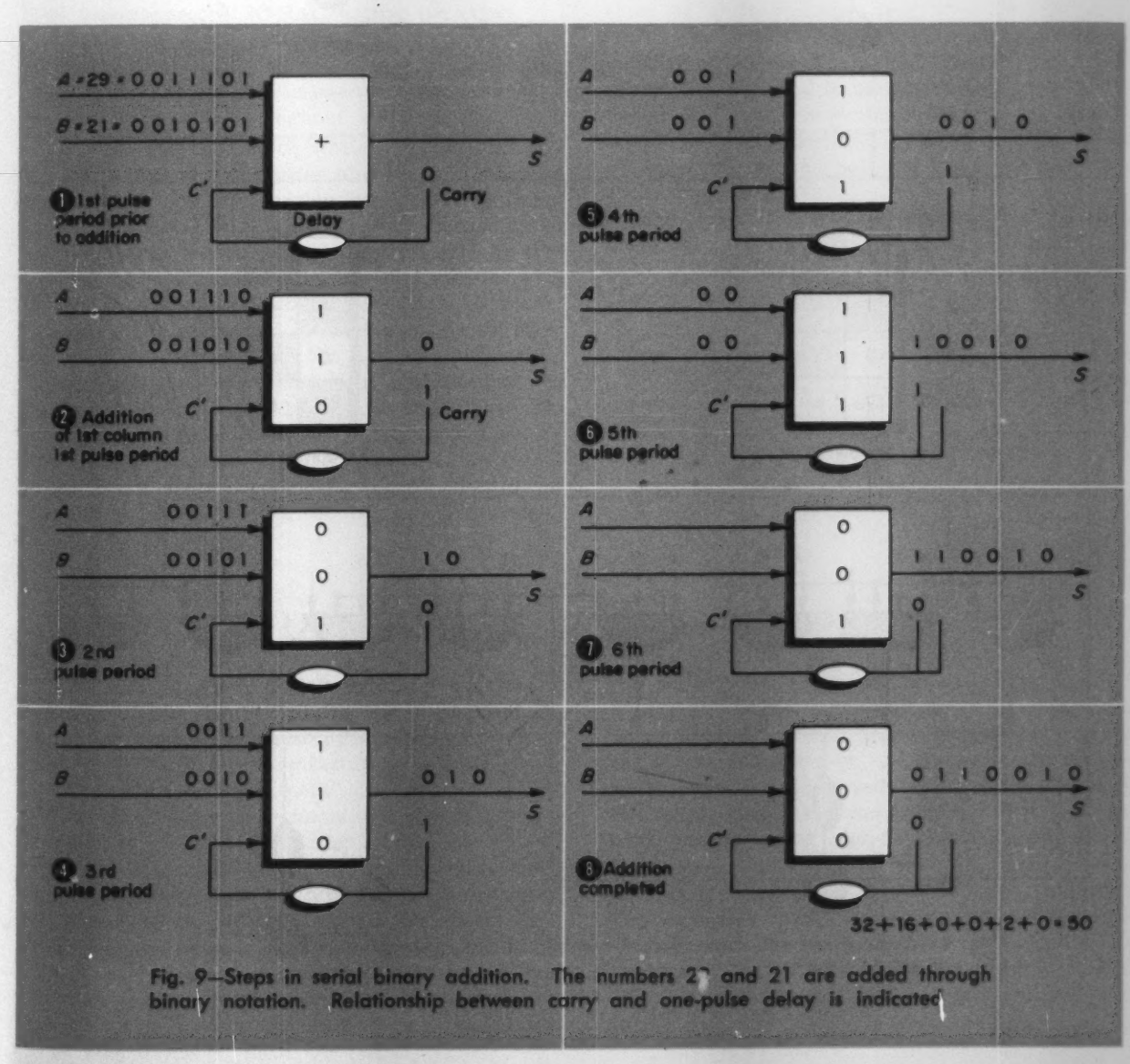


Fig. 9—Steps in serial binary addition. The numbers 29 and 21 are added through binary notation. Relationship between carry and one-pulse delay is indicated

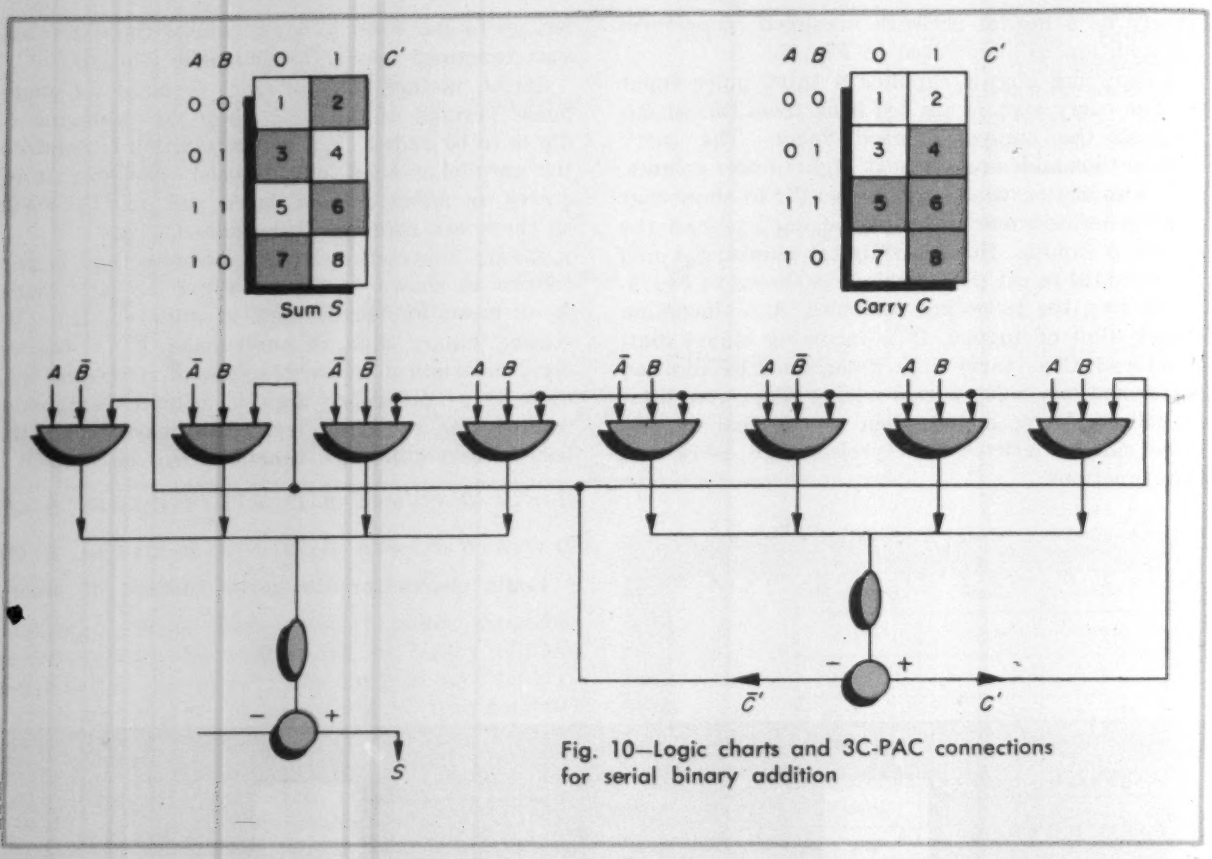


Fig. 10—Logic charts and 3C-PAC connections for serial binary addition

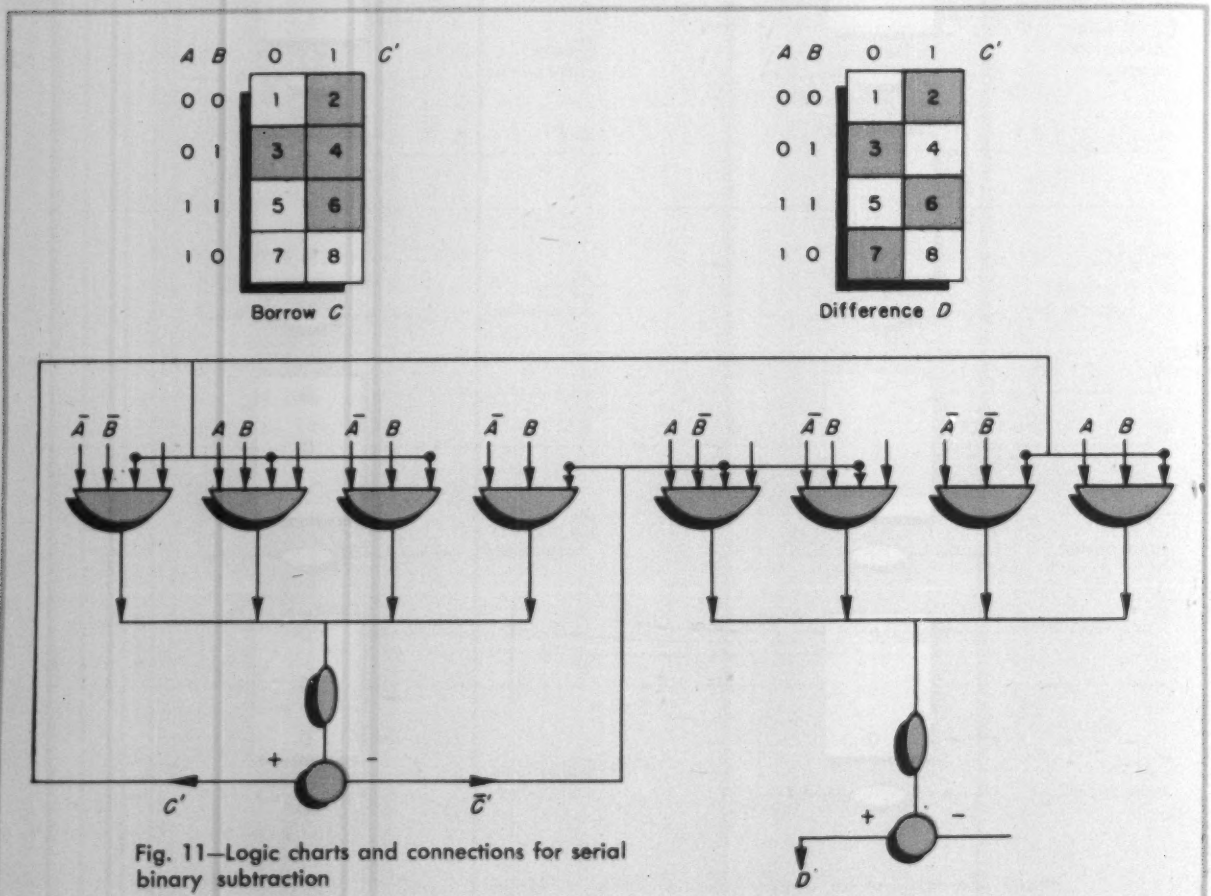


Fig. 11—Logic charts and connections for serial binary subtraction

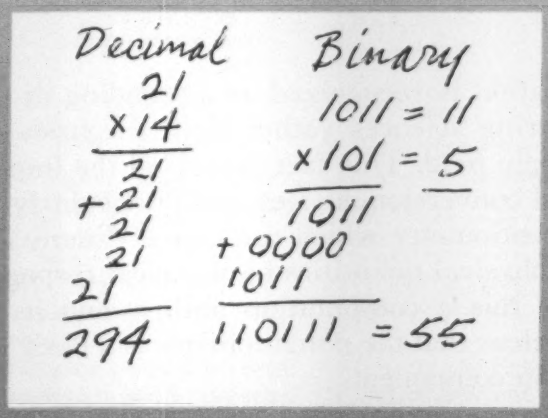


Fig. 12—Decimal and binary multiplication by register shifting and addition

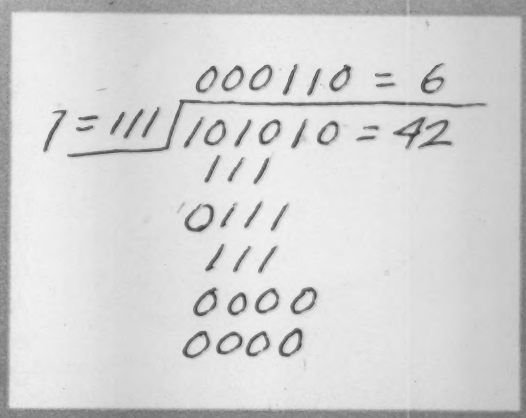


Fig. 13—Binary division by the conventional method of trial multiplication and subtraction

subtraction are shown in *Fig.* 11. These borrow and difference functions can be implemented with two interconnected 3C-PAC gating packages.

Nearly all other mathematical operations can be reduced basically to addition and subtraction operations. However, accessory operations may be required, such as register shifting.

In *Fig.* 12, the multiplication of decimal and binary numbers by register shifting and addition is depicted. Binary division by the conventional method of trial multiplication (or addition) and subtraction is shown in *Fig.* 13. Such step-by-step computing programs are easily implemented with 3C-PACs and appropriate pulse delays. Function generation is performed by implementing an algebraic series expansion of the desired relationship. Integration and differentiation are handled by binary numerical methods. These involve basic addition and subtraction operations, programmed by the logical interconnection of elements.

Registers serve as repositories for digital information. While storing such digital information, it is often desired to shift the time sequence or relative space position of the pulses. The functions of shift registers may thus include serial read-in and read-out, parallel read-in and read-out shifting of information to right or left, etc. These operations are used in parallel-to-serial and serial-to-parallel code conversion, storage of information, binary arithmetic operations, and conversion of pulse information between low-speed and high-speed systems.

Other uses for the gating package include translation of codes such as conversions of teletype code to IBM code, Gray code to binary code, and decimal code to binary code.

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ULTRASONIC POWER SUPPLY

LOW-COST, high-frequency rotating generators, ranging in size from 2 to 150 kw, have been developed by Acoustics Associates Inc. of Glenwood Landing, N. Y. for manufacturing operations involving ultrasonic equipment.

The alternators are capable of supplying economical power for energizing multiple arrays of above-audible sound generating transducers needed to irradiate materials and products being processed en masse, as in degassing molten metals, plating, cleaning and degreasing, or energizing groups of dip or tool soldering stations as well as drilling, cutting and grinding machines. Laboratory ultrasonic experimentation can now be extended into full scale plant production.

In place of the more complex electronic equipment normally used, the new system involves banks of ceramic-type piezoelectric transducers which may be submersed or externally mounted in existing equipment and which are driven by the appropriately rated high-frequency, motor driven alternator. Each transducer will cause copious cavitation through a large field in the solution. The explosive forces caused by the collapse and formation of the large numbers of trapped vapor bubbles at the rate of 20,000 times per second is in the order of several hundred atmospheres pressure.

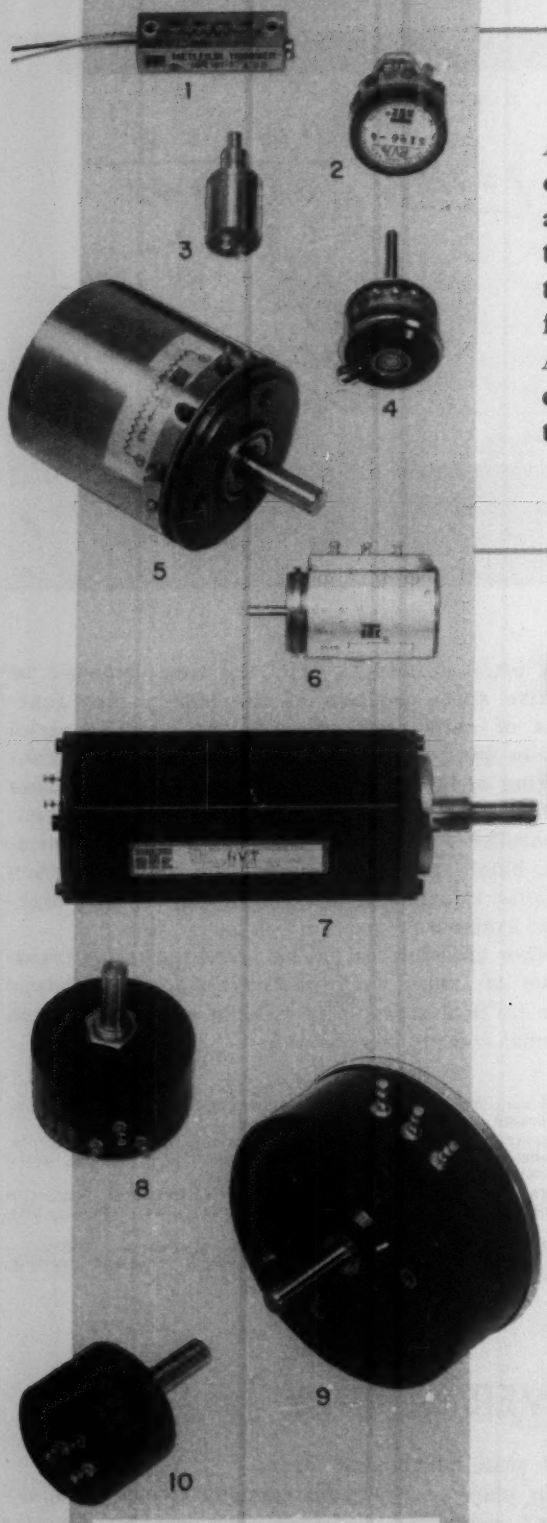


Fig. 1—Large variety of precision potentiometers in current use. Variety is so great that optimum selection for a specific application is often a difficult task. Numbers 1 through 3 are trimmers, 4 a half bearing, 5 and 6 ten-turn potentiometers, 7 a translatory potentiometer, 8 through 10 low cost bakelite potentiometers

Automation is recognized as a blending of the engineering sciences rather than emphasis on any single field. This fact points up the importance of conversion devices, and particularly, of the potentiometer which can convert many different physical quantities to electrical response. Add to this a computation ability, and it becomes clear that the potentiometer is a basic automation component

USE RESISTANCE POTENTIOMETERS

FOR AUTOMATION

By **HOLLIS L. GRAY, Jr.**
Sales Engineering Manager
Technology Instrument Corp.
Acton, Mass.

POTENTIOMETERS are the basic data conversion elements of electromechanical analog equipment. Their extreme versatility has resulted in wide diversity of applications based on an ability to measure voltage accurately. Equipment making extensive use of their characteristics is generally quite flexible, permitting wide range adjustment, and relatively easy modification to meet special requirements. To satisfy the specialized demands of design engineers, manufacturers offer a varied selection of potentiometer types, *Fig.* 1, exhibiting premium performance, and at surprisingly low cost.

Although there are many types of potentiometers, the outstanding importance of the resistance potentiometer will make it the focal point of this article. Even among resistance potentiometers, the variety is so great that optimum selection for a specific application is often a difficult task. Principal areas of application of the resistance potentiometer include servomechanisms and feedback regulating systems, transducing and measuring devices, and general and special purpose analog computers.

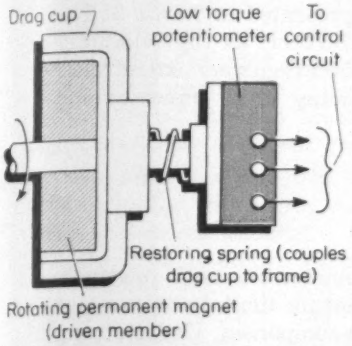

Drag cup
Low torque potentiometer
To control circuit
Restoring spring (couples drag cup to frame)
Rotating permanent magnet (driven member)

Fig. 2—Speed measuring circuit. The potentiometer is deflected against the spring and delivers a speed sensitive voltage

$P_1 + h_1 = P_2 + h_2$; $h_1 + h_2 =$ constant (k)

$P_{1,2}$ = inches of fluid

$h_{1,2}$ = inches

$R_1 \propto H - h_1$ = resistance in left column

$R_2 \propto H - h_2$ = resistance in right column

$$\frac{R_1}{R_2} = \frac{H-h_1}{H-h_2} = \frac{H-h_1}{H-k+h_1}$$;

by substitution and simplification

$$\frac{R_1}{R_2} = \frac{(2H-k)-(P_2-P_1)}{(2H-k)+(P_2-P_1)}$$

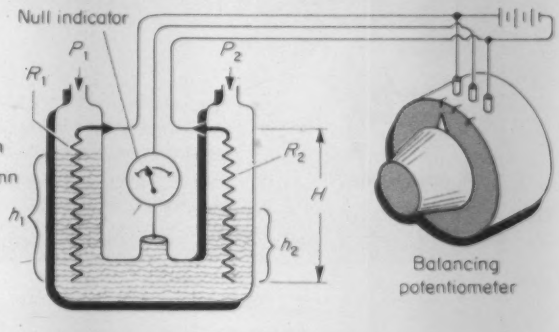


Fig. 3—Potentiometer balancing circuit that directly measures pressure differentials. Balancing may be accomplished either manually or automatically. The pressure differential may be taken from a Venturi flowmeter. If the balancing potentiometer were linear, a linear dial calibration would read directly in differential pressure

Applying Resistance Potentiometers

Applications of resistance potentiometers are so varied in number that many possible classifications based upon application are possible. The following will describe many specific applications, and will so group them as to give some measure of classification.

Among the basic properties of a resistance potentiometer is its ability to transform a mechanical motion to a corresponding variation in electrical resistance. This is clearly a fundamental process in equipment of electromechanical nature. An important application of this property is the conversion of a motion to an electrical signal for purposes of measurement. Related applications include conversion of other physical phenomena readily available as mechanical displacements. The variety of such phenomena is extremely great, with examples scattered throughout industrial plants. TABLE 1 lists some of the most common; *Figs.* 2 through 6 illustrate practical examples of this generalized potentiometer application.

Part of the measurement technique relative to resistance potentiometers is related to the many transducing devices whose outputs manifest themselves as resistance changes. Various circuits based upon the use of servomechanisms and feedback potentiometers are used to transform resistance changes into useable response. TABLE 2 presents a tabulation of a variety of transducers commonly used in industrial control installations, specialized equipment, etc., and requiring associated potentiometers to perform useful control functions.

Another principal area for potentiometer application is in the field of computation. Intrinsically, a potentiometer is capable of providing an electrical output signal proportional to the product of an input electrical signal and a shaft rotation. In conjunction with servomechanisms which are capable of converting between electrical signals and shaft motions, the potentiometer can perform all the fundamental operations of mathematics. Flexibility of computation is enhanced by special circuits and the use of nonlinear potentiometers, *Figs.* 7 and 8.

Two typical computation problems in which precision potentiometers play a major role are illustrated in *Figs.* 9 and 10. The former is an idealized problem in ballistics, such as might be solved

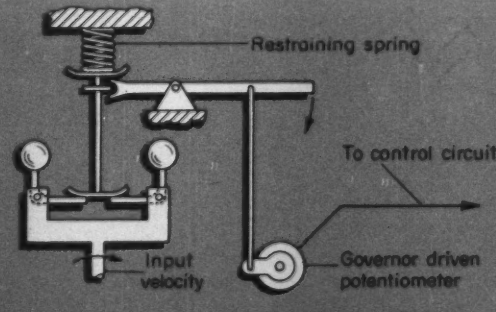


Fig. 4—Speed control circuit employing a potentiometer as data converting device

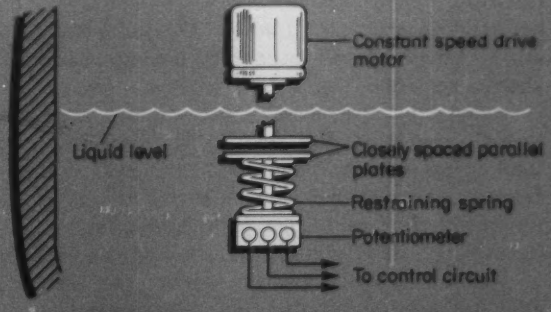


Fig. 5—Apparatus for viscosity measurement. Deflection of the potentiometer is a measure of viscosity

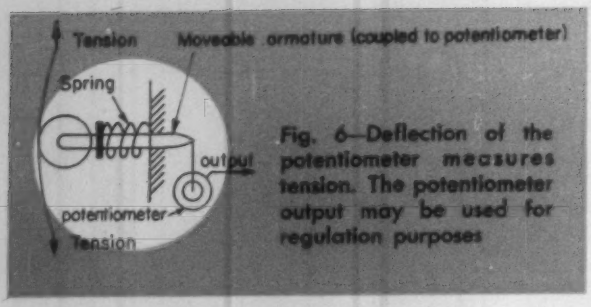


Fig. 6—Deflection of the potentiometer measures tension. The potentiometer output may be used for regulation purposes

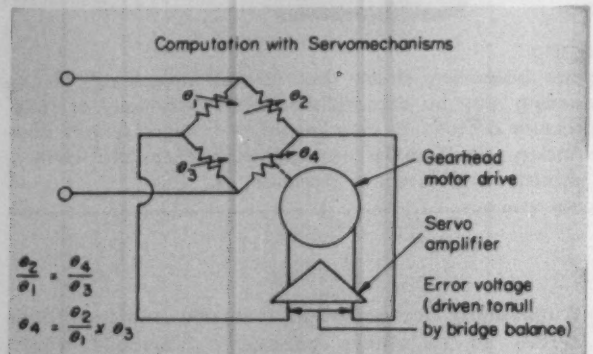

Computation with Servomechanisms
Gearhead motor drive
Servo amplifier
Error voltage (driven to null by bridge balance)

Fig. 7—Servomechanism employing potentiometers as variable resistors for performing multiplication and division operations on shaft displacement variables. This arrangement provides simultaneous multiplication of two shaft angles and division by a third

as part of a problem in gunfire control. A projectile is fired at an angle of elevation θ from the horizontal. Required are its x and y co-ordinates as functions of time. The problem is idealized and simplified by the neglect of air resistance. Additional ballistic corrections, often employing nonlinear functional potentiometers, would form part of an actual military computer.

A typical application of potentiometers to a curing problem such as might be found in a processing plant is shown in *Fig.* 10 and is representative of a large number of processing problems. This particular illustration relating to the time required for curing a material under varying temperature conditions, given the fixed relationship between cure time and temperature, demonstrates the great flexibility of electromechanical computers. These are particularly useful where the independent variable (temperature) cannot be closely stabilized or should be varied for other reasons.

An additional area of potentiometer application, and a very important one, is in the field of open-loop adjustment and control. In *Fig.* 11 is a circuit for precisely obtaining phase shifts of ± 90 degrees, independent of variations in line frequency. Shown in *Fig.* 12 is a circuit for the speed control of a small motor. Gain-control devices in ac and dc equipment, frequency adjustment of resistance-capacitor oscillators, scale changing on various type meters, voltage control adjustment of parameters, etc., fall into this group.

Additional applications of some of the specialized potentiometer types are presented in TABLE 3. The listing will be extended further, as the reliability and versatility of these potentiometers extend their utility as the heart of many vital processes and techniques of automation.

Design Problems

The resistance potentiometer has until relatively recently suffered from certain limitations more or less characteristic of this component. Under strong pressure by systems engineers to overcome these limitations, potentiometer manufacturers have,

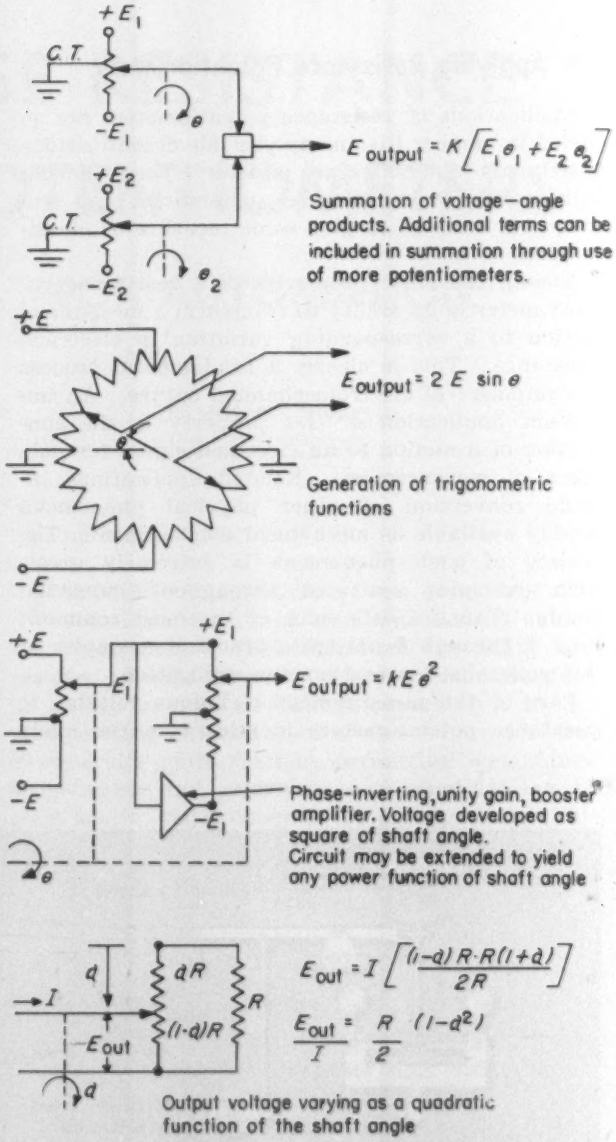

Summation of voltage–angle products. Additional terms can be included in summation through use of more potentiometers.
Generation of trigonometric functions
Phase-inverting, unity gain, booster amplifier. Voltage developed as square of shaft angle. Circuit may be extended to yield any power function of shaft angle
Output voltage varying as a quadratic function of the shaft angle

Fig. 8—Four applications of resistance potentiometers to problems of computation

during and since World War II, succeeded in confining these limitations to practical limits. Thus, potentiometers today do not limit performance of equipment designed to meet even the most extreme operating conditions. Nevertheless, it is well to be aware of problem areas when specifying potentiometers for stringent requirements.

The chief problem which had to be overcome related to the wiper arm which makes contact with the resistance element. Wear, effect of foreign bodies such as dirt or particles originating directly from wear, wiper fatigue, wiper natural resonance, high speed contact, and generation of annoying radio interference, had long plagued the potentiometer designer. Solutions were found in increased knowledge of materials and wiper design techniques, and use of improved seals which minimize entrance of foreign matter. Contact resistance may occasionally introduce errors, especially when the potentiometer is to be employed as a rheostat. Although service life is especially sensitive to rotational speed, normal location of the potentiometer at the low-speed end of a gear train adapts it to many requirements. Often a parallel pair of wipers is employed to improve resolution and reliability. Low-torque potentiometers requiring minimum brush pressures are especially sensitive to wiper problems, often exhibit very high contact resistance, (hundreds of ohms), and therefore require the most careful design.

A related area of potentiometer research which is challenging designers of guided missiles and other key military equipment, is resistance to environmental extremes. Increasingly stringent military standards, particularly for missile applica-

Table I

MEASUREMENTS WITH RESISTANCE POTENTIOMETERS

Quantity	Method
PRESSURE	Motion of expansion bellows under pressure causes corresponding wiper displacement of a coupled low torque potentiometer.
PRESSURE	Bourdon tube coupled to low torque potentiometer.
DIMENSION	Potentiometer actuated by a rack and pinion serving as an electrical dial indicator. With good potentiometer resolution, unusual flexibility may be achieved, including such features as remote indication, expansion of scale so as to use full visible range to cover the allowable tolerance, very light contact load, and the actuation of a signal device for out-of-tolerance parts. An electrical roughness gage may operate in the same manner.
ACCELERATION	Spring mounted mass actuates a potentiometer during acceleration.
TEMPERATURE	Potentiometer actuated by a helical bimetallic strip.
LIQUID LEVEL	Potentiometer actuated by the force of a partially submerged float. Motion against a restraining spring may be any function of liquid level depending upon the shape of the float, the characteristics of the spring, or the nonlinearity of the potentiometer.
WEIGHT	Potentiometer may measure the displacement of the elastic member of a scale. The output signal can be used to control quantity percentages or rate of weight variation.

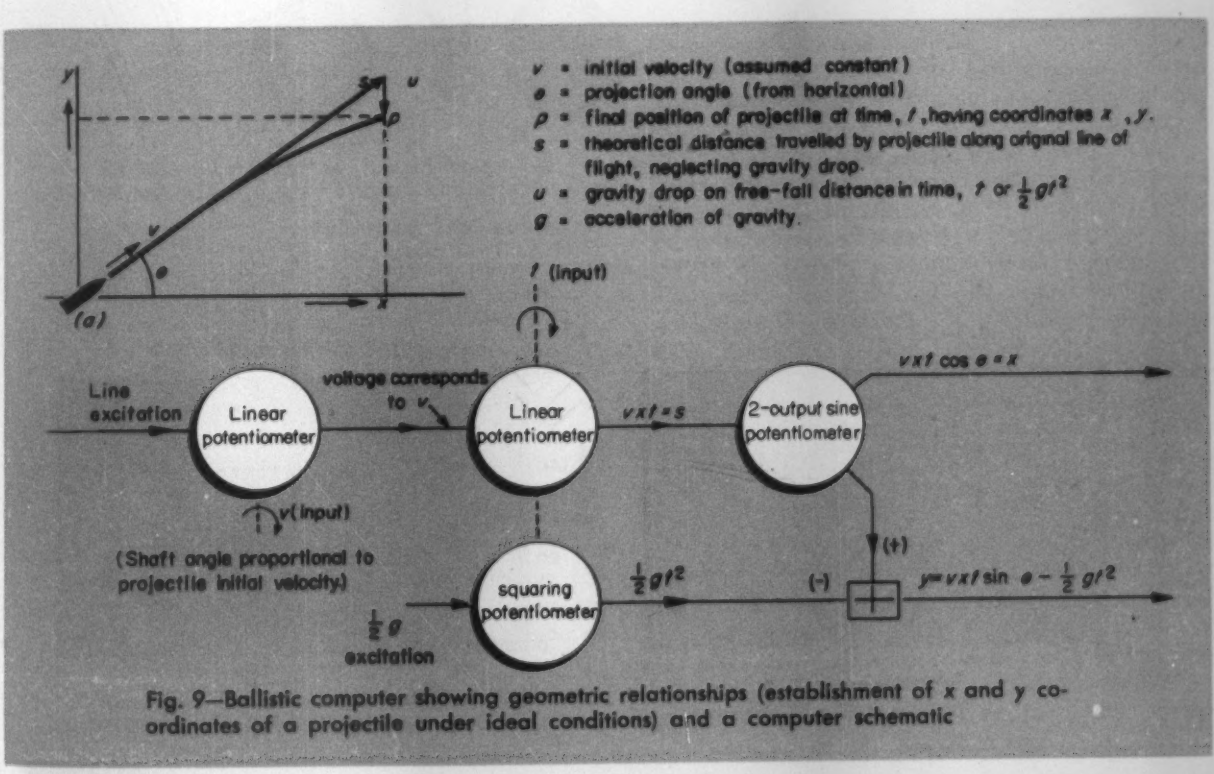


Fig. 9—Ballistic computer showing geometric relationships (establishment of x and y coordinates of a projectile under ideal conditions) and a computer schematic

Table II

TRANSDUCERS PRODUCING A RESISTANCE VARIATION AS OUTPUT

Strain gage
Hot wire fluid flow meter
Temperature sensitive resistor
Pressure sensitive carbon pile, or carbon microphone
Moveable grid vacuum tube
Conductivity cell (for measurement of pH, liquid purity, or other properties)
Resistance springs
Photosensitive semiconducting cells
Carbon arc
Humidity sensitive resistor
Voltage sensitive resistor
Current sensitive resistor
Bolometers for detection of infra red
Thermostat (as on-off device)
Bismuth resistor (sensitive to magnetic field strength)
Controlled electron tube, or semiconducting element
Level indicator for conducting liquid

tions, are forcing present performance limits to regions thought impractical only a few years ago. High temperature extremes, and contact reliability at low temperature and high speeds are the critical environmental conditions. Current upper limits of temperature surpass 350F.

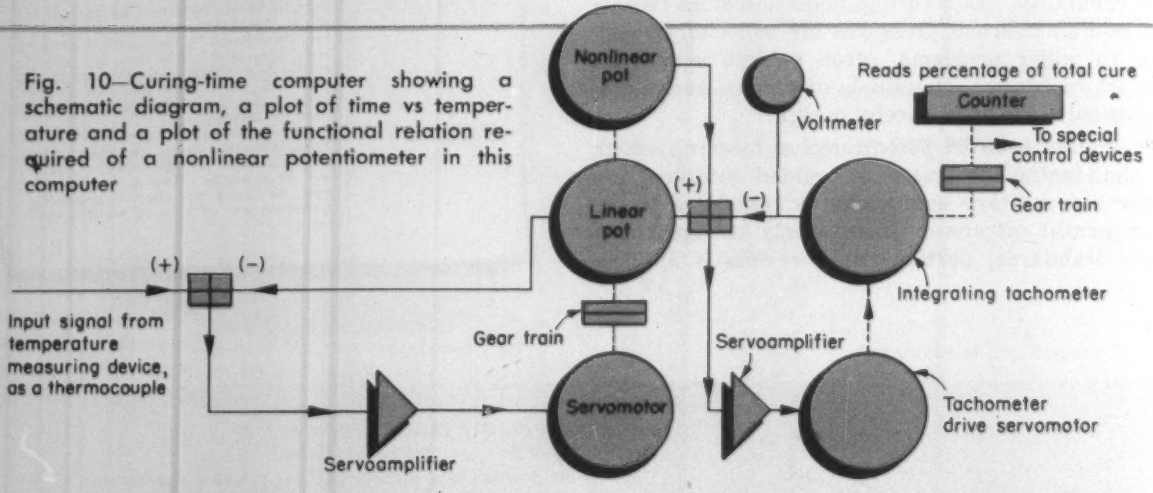
Other basic potentiometer application factors include the sensitivity to loading which is characteristic of the potentiometer by virtue of its high ratio of output to input impedance. Although the potentiometer can be designed to compensate for loading errors, being a resistive device, it is a relatively inefficient means of power transfer.

Resolution and dynamic behavior must be specified for closed-loop performance where loop-stability limits are often established by the potentiometer itself.

Potentiometer Standardization

Precision, low-price, mass-produced potentiometers are a relatively recent arrival on the com-

Fig. 10—Curing-time computer showing a schematic diagram, a plot of time vs temperature and a plot of the functional relation required of a nonlinear potentiometer in this computer

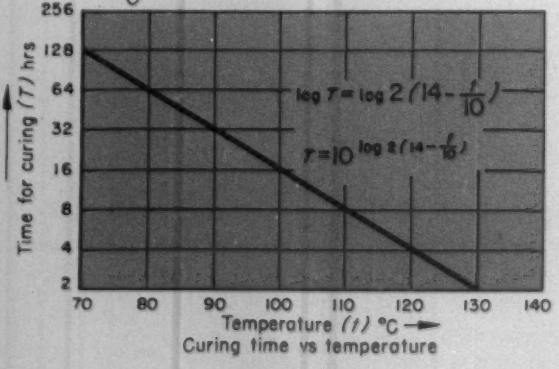


For t variable, the percentage of total cure in time dT is given as

$$\frac{dT}{10^{\log 2\,(14-\frac{t}{10})}} \times 100$$

Total cure is achieved when

$$\int_0^T \frac{dT \times 100}{10^{\log 2\,(14-\frac{t}{10})}} = 100;\ t = \text{function}\ (T)$$

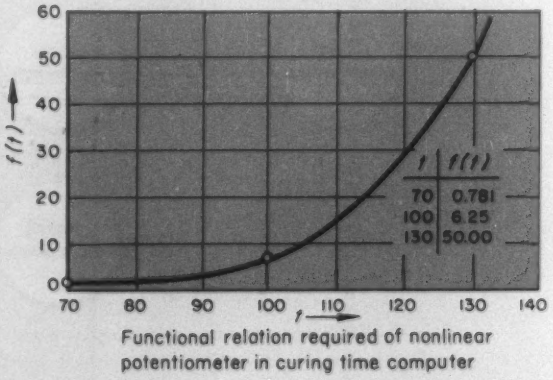


Simplification of the Potentiometer Equation
(as required to generate this integral automatically)

$$\text{Function to be generated} = \frac{100}{10^{\log 2\,(14-\frac{t}{10})}} = f(t)$$

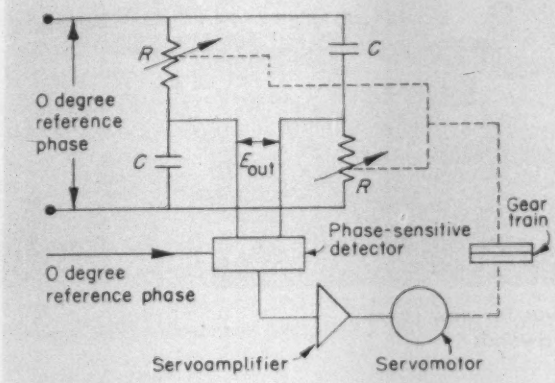
$$f(t) = \frac{100}{10^{14 \log 2} \cdot 10^{(-\log 2/10)t}} = \left[\frac{100}{10^{14 \log 2}}\right] 10^{\frac{\log 2}{10} t}$$

$$f(t) = 10^{-2.214} \cdot 10^{0.0301 t} = 10^{(0.0301 t - 2.214)}$$



Functional relation required of nonlinear potentiometer in curing time computer

ponent scene, and are consequently further from standardization than related components, such as synchros and servomotors. As a matter of fact, "specials", or design variations, constitute a very significant portion of the precision potentiometer market. The enormous variety of possible useful variations is imposing a severe restraint on attempts to establish standards. Key areas into which special designs may be grouped are mechanical (physical appearance and characteristics,



E_{out} = 90 degree phase-shift voltage, of constant amplitude with respect to the reference phase

C = stable, matched condensers

R = matched, ganged potentiometers used as variable resistors

Fig. 11—Precision circuit for obtaining 90 degree, frequency independent, reference phase

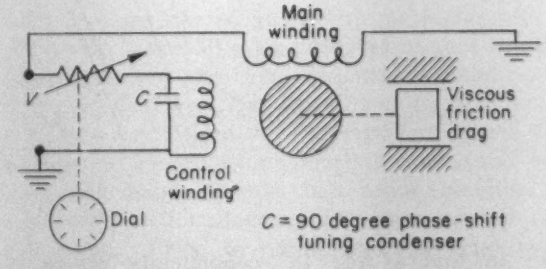


Fig. 12—Speed control circuit for small 2-phase servomotor. For linear control, a nonlinear potentiometer is required

external connections, special environmental features, life) and electrical (accuracy and conformity, resolution, power rating, contact characteristics).

Each of these categories may be tailored by the potentiometer manufacturer to specific design requirements. Often, special optimization of one or more of these features may yield substantial system simplification.

Notwithstanding the emphasis on specials, some degree of standardization has been achieved by

Table III

MISCELLANEOUS POTENTIOMETER APPLICATIONS

1. **Trimming Potentiometers:** Used to adjust total resistance and independent linearity of precision potentiometers, zero setting, gain setting, cancellation of residual voltages and pickup

2. **Linear Motion Potentiometers:** Used to convert between linear motion and voltage without rack and pinion normally required with a rotary potentiometer. Typical applications include measurement of the displacement of machine tool tables, pressure bellows, electrical micrometers, strain gages, coordinate measuring devices in X, Y recorders

3. **Nonlinear Potentiometers:** These are used to generate empirical functions, for computation, for compensation of undesired nonlinearities, as electrical cams, for many applications in chemistry and the process industries, problems involving trigonometry, such as are encountered in fire-control and ballistics, and analog computers. Also used for generation of wave forms, such as saw-tooth, square, and other special forms required for computers, radar sweeps, etc. Useful where a low and easily adjusted repetition rate is required. A sinusoidal potentiometer driven by a motor is used as a low frequency sine-wave oscillator. Special potentiometers are used for generation of step functions and square waves

individual manufacturers, with popular models obtainable in roughly equivalent form from a variety of sources. Two standardization groups, a Radio, Electronics, Television Manufacturers Association (RETMA) potentiometer subcommittee, and an Aircraft Industries Association (AIA) committee are currently preparing standards for precision potentiometers, which should do much to clarify definition and method of measurement. Certain potentiometers by their popularity and wide availability might be regarded, roughly speaking, as standards. Because of high production, these precision units, thoroughly engineered to stringent specifications, are low in cost, which has caused potentiometers to invade fields hitherto uneconomical or marginally satisfactory performance-wise.

A significant factor in cost reduction of highly accurate units has been the application of automation techniques to the process of potentiometer manufacture itself. One common method requires the continuous monitoring of electrical resistance during the winding of the resistance element. Servo-controlled variation in wire spacing is employed to make continuous corrections in resistance a function of geometry to insure highest accuracy. By this method, it is possible to achieve accuracies of better than 0.01 per cent economically on a production basis. This technique is also adapted to nonlinear potentiometers where maximum conformity is required. Automatic techniques are presently being exploited by more and more manufacturers. Other improved methods are currently undergoing laboratory development.

Fig. 1—Digester building, wood yard and wood loading conveyor for new chemi-groundwood plant to produce pulp for newsprint from hardwoods

RESEARCH PLUS AUTOMATION PRODUCES

NEWSPRINT FROM HARDWOODS

By G. W. GASSETT
Instrument Engineer
Stone & Webster Engineering Corp.
Boston, Mass.

HOW TO meet increased demand for newsprint when supply of conventional raw material is already inadequate is a growing problem in the paper industry of the United States. In 1953, newsprint consumption in the United States reached 6.1 million tons with only about 20 per cent of that quantity produced in this country. The estimated consumption for 1975 is 8.7 million tons—a challenging increase.

Historically, newsprint has been produced from softwoods such as spruce, pine, fir and hemlock —woods for which consumption has been continually exceeding their growth in the United States. Growth of hardwoods such as poplar, maple and birch has been estimated to exceed their consumption in the United States as much as 20 per cent, and the supply in the Lake States and New England regions is plentiful. A major problem has been to find a way to economically utilize the hardwoods to help meet newsprint demand.

Co-operative research and modern processing equipment have now opened a path by which hardwoods can be used in newsprint economically. In 1950, Professors C. E. Libby and F. W. O'Neil of Syracuse University published a report covering research sponsored by a group of 28 paper companies incorporated under the name Empire State Paper Research Associates Inc. Their report brought out two facts of major importance to the newsprint industry: That chemical treatment of hardwood as logs, with subsequent grinding to pulp, produced stock which could be used to replace some of the softwood pulp in newsprint production; and, that the overall cost of such an operation would be no more than that for direct grinding of softwood and very much less than the ex-

pense of producing chemical sulphite pulp. The new process for chemically treating hardwood logs and then grinding them was named the chemi-groundwood process.

Largest producer of newsprint in the United States is the Great Northern Paper Co. whose timberlands contain great stands of hardwood, formerly unused in their operations. The chemi-groundwood process had special appeal to this producer, and they built and operated a pilot plant with a capacity of 50 tons per day to utilize and study this new process. Operation of this pilot unit proved that the chemi-groundwood pulp produced from most hardwoods could be used in the manufacture of quality newsprint. On the basis of these results, Great Northern proceeded with plans for the expansion of their manufacturing facilities at East Millinocket, Maine. They engaged Stone & Webster Engineering Corp. for the construction of the project and for design of the new power plant and the chemi-groundwood unit, *Fig.* 1. The design work included the detailed design of the digesters with complete hydraulic control systems, conveyor systems and instrumentation which involved many features unique to the paper industry.

Chemi-groundwood Process

Hardwood logs 4 feet long are carried from outdoor storage piles by a 500-foot conveyor to the top of the digester building. At this point they are discharged into a turntable hopper which is positioned by an electric motor operator and feeds the logs to any one of the digester loading chutes. These chutes are steel enclosed and discharge directly into the vertical digesters through the charging doors located at the top platforms. Electrical safety interlocks are provided so that the log loading conveyor and turntable motor cannot operate simultaneously. The individual digester loading chutes are raised and lowered on hinges for charging by means of an electric hoist, and the mechanical design is such that, when the chute is up out of position, logs cannot pass beyond the hinge point. Prior to charging a digester with logs, "padding" water is introduced to fill about 65 per cent of the digester volume in order to break the fall of the logs in charging. After approximately 25 cords of wood have been charged to the digester, the padding water is removed and the top cover is closed and bolted.

A vacuum of approximately 28 inches of mercury is drawn on the sealed vessel for 30 minutes, after which neutral sulphite liquor is introduced and the pressure brought up to 150 psi gage by means of a "pressuring" pump. The liquor is raised to cooking temperature by circulation through an external steam heated heat exchanger and this temperature is held for about four hours. The rate at which the temperature is brought up, the temperature which is held and the length of time it is held all depend on the type and quality of hardwood being treated. During this part of the operation the impregnation of the wood with the liquor softens the wood binders, thereby converting the hardwood to a form which is readily handled by pulp grinders.

At the conclusion of the cooking period, the pressure on the digester is relieved and the liquor blown back to an accumulator. When the digester has been bled down to atmospheric pressure and remnants of cooking liquor drained off, the bottom door is opened by a hydraulic system which controls release of the locking ring and door bolts and opens the door on its hinges by means of two door cylinders.

As the door opens, *Fig.* 2, the cooked logs are discharged to a water-filled concrete pit below the digester. The water breaks the shock of the fall

Fig. 2—Hardwood logs 4 feet long are processed in batches of about 25 cords per digester charge. Picture shows a batch being discharged from the bottom of a digester. Operations were started with two digesters and provision for ultimate installation of six units

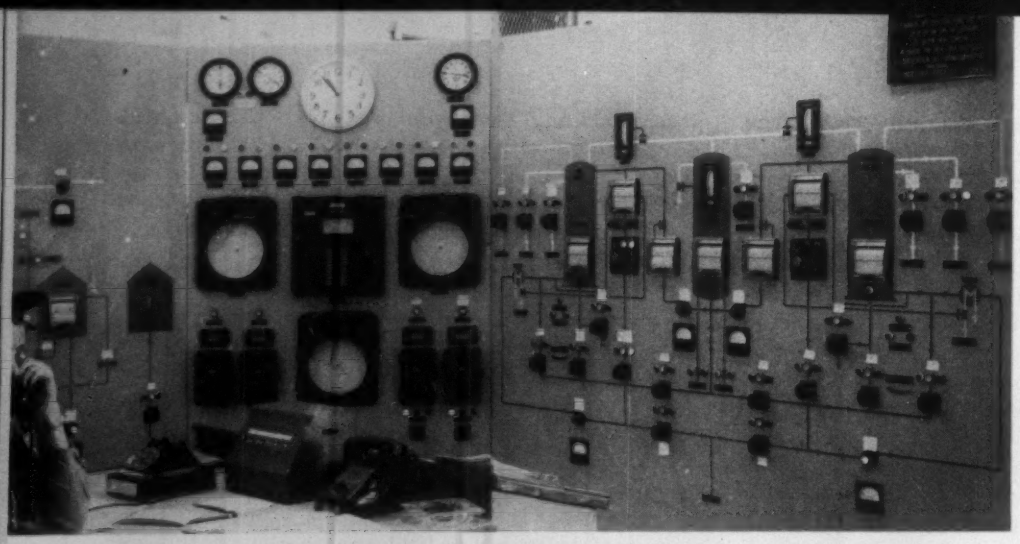


Fig. 3—Most of the operations may be observed and controlled from this station located near the bottom of the first two digesters. Flow lines on the graphic panels are color coded to indicate the materials in the systems

and leaches some chemicals from the wood, as well as cooling the logs to permit easier handling. The logs are then transferred by grapple crane to a conveyor which takes them to the grinders.

Chemical Handling

During the cooking, "cooking liquor" is absorbed by the logs. The liquor level in the accumulator is replenished from time to time by the introduction of fresh "white liquor," together with a suitable quantity of dilution water. The white liquor is prepared in batches by circulating 18 per cent soda ash solution in an absorption tower countercurrently to burner gas containing approximately 11 per cent sulphur dioxide (SO_2). The SO_2 is produced by burning atomized liquid sulphur in a refractory burner under controlled conditions. The hot burner gas is quenched in the lower section of the absorption tower by evaporation of some water from the solution.

Light soda ash is received in hopper-bottom cars, conveyed pneumatically and washed into a slurry storage tank. Make-up water is automatically added to the tank to dissolve the soda ash in the slurry. The advantage of storing the soda ash in a slurry is that a larger quantity of the chemical can be stored in a given volume. A temperature of 100F in the slurry is maintained to insure a constant concentration in the saturated solution. Soda ash is added to the tank by means of a mixing nozzle which makes it possible to unload soda ash from a hopper bottom freight car using a vacuum system without blowing soda ash into the surrounding air.

Supernatant solution at 100F or higher containing 33 per cent by weight of soda ash is fed to the sulphiting operation. The saturated soda ash solution is diluted with water in one of the sulphiting tanks to a concentration of about 1.8 pound of soda ash per gallon. The dilute solution is then circulated from tank to absorption tower for four hours and reacts with the SO_2 in the burner gas to form sodium sulphite. Control is important since over-sulphiting would result in the formation of excessive amounts of sodium bisulphite, which, at elevated operating temperatures, breaks down to release SO_2 and form sulphurous acid. It is also essential to convert all bicarbonate to sulphite to prevent subsequent carbon dioxide evolution in the digesters with attendant corrosion. The solution is next buffered with soda ash to maintain alkalinity and thus avoid corrosion.

Sulphur, also received in hopper cars, is unloaded directly into a pit underneath the freight car and transferred to a storage silo by a screw conveyor and bucket elevator combination. The sulphur is discharged from the silo to an intermediate weigh tank which automatically shuts off the conveyors when the predetermined weight of sulphur has been transferred. Sulphur flows from the weigh tank into two steam jacketed melters which discharge the molten sulphur into a steam heated molten sulphur storage tank. A steam turbine driven vertical spindle centrifugal pump moves the molten sulphur to the atomizing burner nozzle.

The sulphite or white liquor plant is designed to produce 48,600 gallons per day of white liquor. The liquor drained from the digester is continuously reused in subsequent cooking, with concentration and alkalinity maintained by make-up. The degree of chemical fortification is about 10 per cent by weight of the wood treated.

Instruments and Controls

Designed to take advantage of current developments in process control, the chemi-groundwood plant has many modern control features. Most of the operations in both the white liquor and digester sections may be observed and controlled from graphic control boards centrally located near the bottom of the first two digesters. This control center is composed of a conventional panel and two "full graphic" panels, *Fig.* 3. On the conventional panel are located utility pressure gages, pump running lights and ammeters, multipoint temperature indicator, multipoint temperature recorder, batch make-up meters for water, soda ash and white liquor, tank selector switches, steam

flow recorder and digester vacuum header pressure recorder. This conventional panel is located between full graphic panels for white liquor preparation and digester operation. The so-called "full graphic" panels consist of color coded, simplified flow diagrams of the entire process with miniature recording, indicating and controlling instruments located in the process layout. Color coding of the lines and equipment is used to indicate the materials being handled. The miniature recording instruments are all identical and have vertical strip charts. Those with controllers are readily operable from the front of the board, although con-

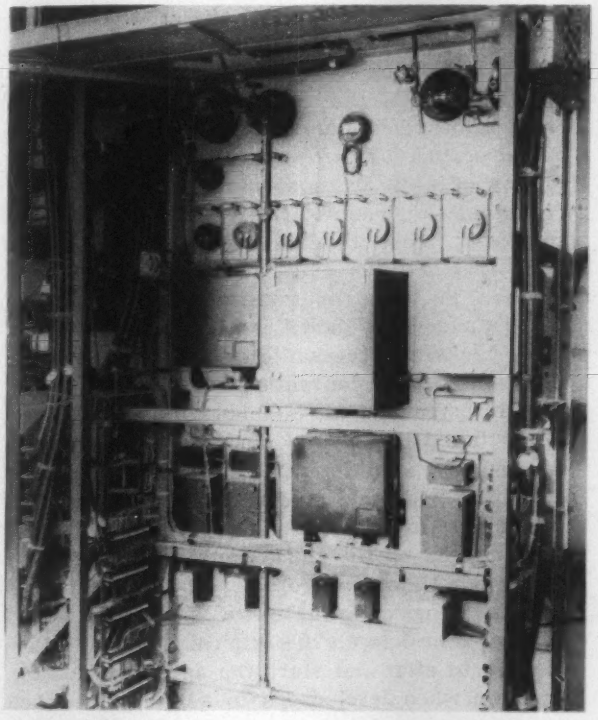


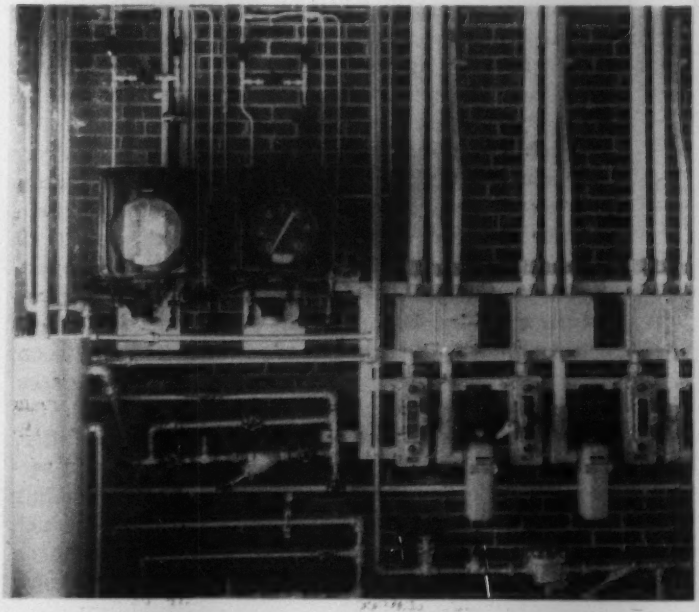
Fig. 4—Instruments, wiring and piping are readily accessible from the rear of the control panel. Control units in the "full graphic" panels plug in from the rear of the panel

trol units, which are of the plug-in type, are located in back of the panel, *Fig.* 4. The automatic control here is operated pneumatically and pneumatic transmission is used for flow, level, pressure and some temperature applications. Other temperature applications, gas analysis and pH are measured and transmitted to the board electrically. There are electrical interlocks and tie-ins with the pneumatic instruments, particularly with respect to the operation of the motorized valves, most of which are manually operable from the graphic panel.

The accumulator and digester levels are measured by means of differential pressure cells with pneumatic transmitters located at the base of the vessels. The pressure taps on each vessel are located so as to cover as much of the level range as possible and the lead lines are continuously purged with water to prevent plugging with dirt, bark or wood fibers. The pneumatic transmitters are spring suppressed to reverse the air output and make it directly proportional to the liquid level in the vessel. Since the digesters operate at 150 psi gage during the cooking cycle, it was necessary to install a separate instrument purging water system with a small pump, controls and piping to provide water at sufficient pressure. Pneumatic pressure switches with adjustable multiple contact points are located behind the control board to operate high and low level lights and to provide electrical interlocking with the padding water pump and motorized valves on the padding water and drain lines. Settings of the motorized valves, whether operable from the control board or not, are shown in the graphic layout by indicating lights.

As the white liquor is brought into the log-filled digester, pressure is brought up to 150 psi gage by starting the pressuring pump from the control board and allowing the recording pressure controller to regulate a diaphragm type valve in the pump discharge line in order to hold the digester at this pressure. For safety this control valve must close on air failure, so the pressure controller increases the output air pressure to the valve whenever the pressure in the digester drops below the control point of 150 psi gage. This action would create a problem when trying to pull a vacuum on the digester, so a three-way solenoid valve is installed at the control valve diaphragm. When the pressuring pump is operating, the solenoid is energized, allowing the pressure controller to open the valve. When the pump is stopped, the solenoid is de-energized, allowing the diaphragm pressure to bleed to atmosphere and the

Fig. 5—Control of make-up in batches of soda ash solution is achieved with flowmeters located at orifices in the make-up lines, a flow integrator, timer and totalizer which actuate motorized valves



controller pressure to be dead-ended, thereby closing the valve.

Additional electrical interlocks are provided by the use of pneumatic pressure switches on the vapor relief lines from the tops of the digesters. These interlocks make it impossible to open the motorized vacuum or drain valves when the digester pressure is above 1 psi gage, and also make it impossible to open the steam or blowdown valves when the pressure is above 90 psi gage. The hydraulic system is also interlocked in the same manner, and is inoperable unless the digester is at atmospheric pressure. Indicating lights on the graphic layout show whether the bottom digester door is open or closed, and an alarm light shows if the hydraulic system pressure falls below an operable value at any digester. Pump switches are located in the diagrammatic panel layout with signal lights which indicate whether each pump is running.

Programmed Temperatures

Perhaps the most interesting automatic control feature of this installation is the new temperature controller used here for the first time and known as the "Pneumatic Cyclelog." In the past, many operations involving programmed temperature control have used a timed cam type controller, which meant that a cam would be designed to bring the temperature up to the control point at a definite predetermined rate, hold it at the control point for the required time and then shut the heat off. To obtain greater flexibility the Cyclelog uses an adjustable air bleed and timer in place of timed cams. Pneumatic temperature transmitters are located at the circulating liquor inlet and outlet of the digester, and both temperatures are recorded on a two-pen miniature recorder at the board. Temperature is regulated by means of a pneumatically operated valve in the steam line to the digester heat exchanger. The operator sets the desired rate of rise, the temperature control point index, and holding time before the batch is started. After the digester has been brought up to pressure, the operator initiates the heating cycle by pushing the start button on the Cyclelog unit. This energizes a solenoid valve, which allows instrument air pressure to bleed from a capacity tank through an adjustable restriction to move the control index upscale at a specific rate. This, in turn, increases controlled air output to open the steam valve. The setting of the adjustable restriction determines the rate of temperature rise by the rate at which the air bleeds through it. During this time a green light is on, showing that the cooking cycle is in progress. When the holding temperature is reached, the pneumatic pressures on opposite sides of a differential pressure switch become equalized and a second solenoid is actuated, which cuts the holding timer into the circuit, shuts off the air bleed which increased the control index setting, and turns on an amber light to indicate that the cycle is now in the "holding period." As soon as the time set on the timer has elapsed, the solenoids are deenergized, the steam control valve closes and the lights go off. Control of the steam valve may be based on either inlet or outlet temperature, by manually setting an air switch at the rear of the panel. This controller, as well as other board mounted controllers on this project, is equipped with a complete automatic-to-manual by-pass so that the unit may be operated manually if it becomes necessary to service or repair the instrument.

Auxiliary Controls

The density of the saturated soda ash solution in the slurry storage tank is measured by an internal displacement type level transmitter, which is mounted with the displacer completely submerged below the minimum tank liquid level. Since the temperature of the tank is kept constant, any variation of soda ash concentration or density is reflected in the buoyant force acting on the displacer and torque tube of the pneumatic transmitter. The recorder chart at the control board is calibrated in terms of solution density. Levels in the atmospheric tanks, such as the two sulphiting tanks and the white liquor storage tanks, are measured by a conventional air bubble system in which instrument air is bubbled up through the head of liquid in the tank and the back pressure measured by a differential pressure pneumatic transmitter with the low pressure side vented to atmosphere. Interlocks are provided with the level instruments on the slurry tank to add make-up water when the level drops, except when the solution is being pumped to the sulphiting tanks. The level recorders on the sulphiting tanks are interlocked to stop and start the agitators, to stop the pump when level drops to a low point when pumping out, and to open and close the water make-up valve after soda ash solution has been added to the tank.

Make-up of soda ash solution to the sulphiting tanks and of white liquor and dilution water to the accumulators is accomplished at the common panel by means of selector switches which control motorized valves in lines to the respective tanks. The batch make-up meters are indicating mercury flowmeters located at orifices in the make-up lines. An electric flow integrator actuates a totalizer at the control board, and the timer, calibrated in gallons, is connected with the totalizer so the required flow may be set on the dial and the motorized make-up valve automatically closed when this amount of liquid has gone through the orifice, *Fig.* 5.

The development and instrumentation of this first commercial chemi-groundwood pulp mill is proving of considerable interest, and the graphic panels, together with the hydraulic system for operating the digester doors, provide an installation that is not only practical but unique in the paper industry.

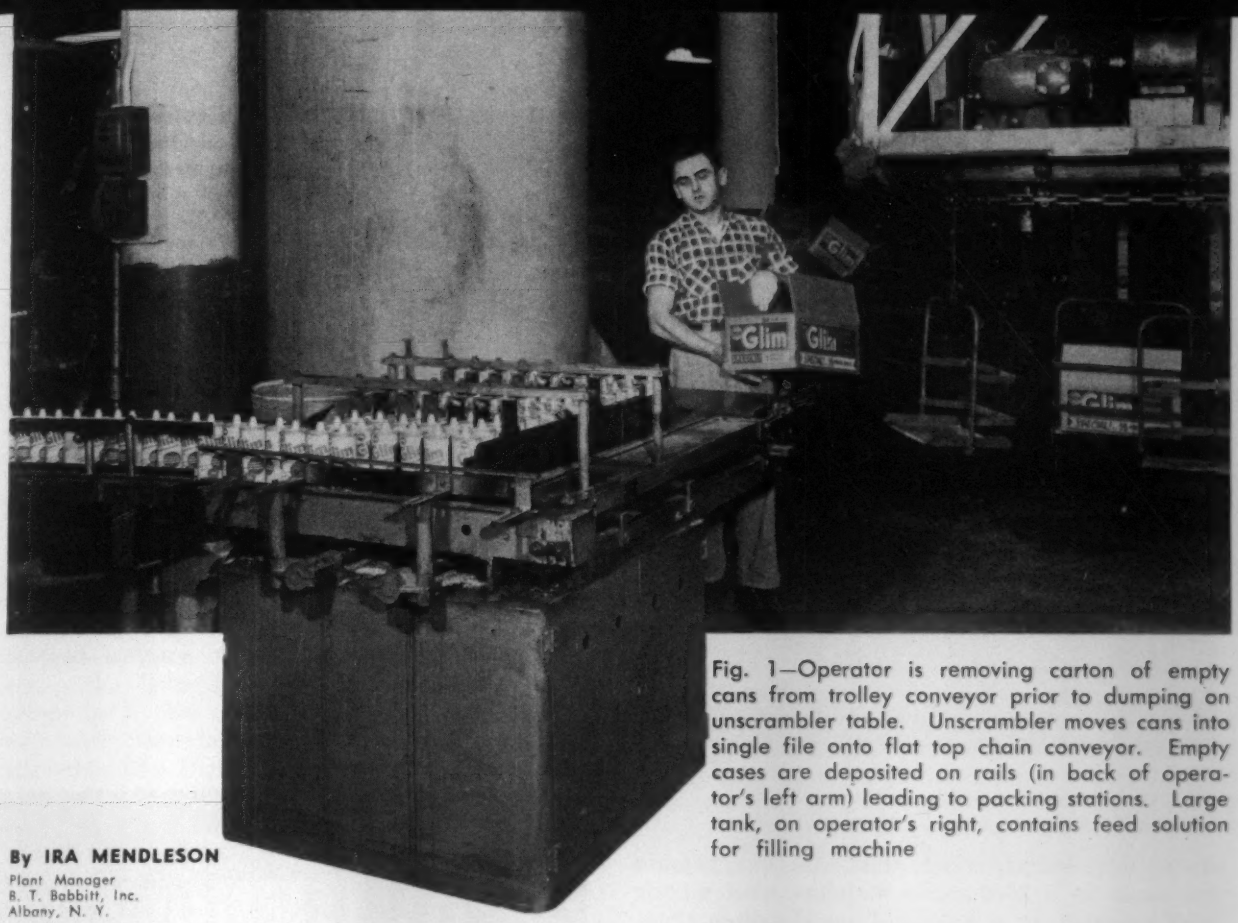


Fig. 1—Operator is removing carton of empty cans from trolley conveyor prior to dumping on unscrambler table. Unscrambler moves cans into single file onto flat top chain conveyor. Empty cases are deposited on rails (in back of operator's left arm) leading to packing stations. Large tank, on operator's right, contains feed solution for filling machine

By IRA MENDLESON
Plant Manager
B. T. Babbitt, Inc.
Albany, N. Y.

X-RAY INSPECTION CHECKS

DETERGENT PRODUCTION LINE

Household soaps and detergents are sold in a highly competitive market. Improvements in the process operations are vital links to low cost production. Increased automation is a key to increased sales

ONE OF THE FIRST of the liquid dishwashing detergents, "Glim", is now manufactured in the Albany plant of B. T. Babbitt, Inc., makers of Bab-O. Glim was initially developed as a non-ionic liquid detergent with no foam stabilizers; however, continuing laboratory development and customer-preference studies showed that an anionic detergent with amide type foam stabilizers was the modern dishwashing compound most attractive to the American housewife. Consequently, today's Glim is a multicomponent solution containing alkyl-aryl-sulfonates, fatty amide and ethoxylated organic foam stabilizers, with water-alcohol-glycol diluents to control physical properties.

Formulation

The process starts with the unloading of tank cars or trucks of detergent slurry. This heavy viscous material is pumped by slow speed positive displacement pumps into a 13,000-gallon stainless steel holding and stirring tank and, after thorough blending, into smaller 6000-gallon stainless steel storage tanks. Samples from these storage tanks are assayed for detergent content and impurities. It has been found that inorganic salts, particularly sodium sulfate, must be kept to a minimum to prevent subsequent cloudiness and other undesirable effects in the finished product.

Based on the analyst's findings, the formulation

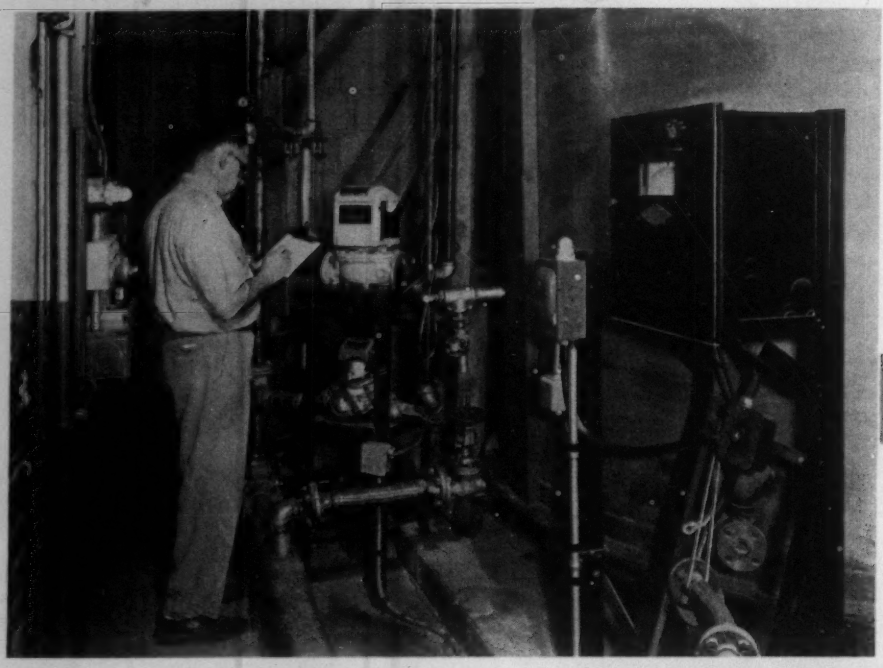


Fig. 2—Formulation recipe is checked in front of 3500-gallon stainless steel mixing tank, which is mounted on a Baldwin SR-4 weighing element. Weight readings are shown on extended scale potentiometer at the right. Electric panel behind operator controls mixer and transfer pumps

recipe is prepared. From this, the Glim batches are made in a 3500-gallon stainless steel mixing tank mounted on a Baldwin-Lima-Hamilton Corp. SR-4 weighing element. While the other ingredients may be metered into this mixing tank by displacement type meters, the detergent slurry contains suspended solids and must be accurately weighed to insure accurate formulation. Accordingly, the SR-4 cell is equipped with an extended scale potentiometer permitting weighing the 27,000-pound batch with a precision of ± 5 pounds. To constantly realize this accuracy, the system is periodically checked by filling the mixing tank with water through a calibrated meter.

When the ingredients have all been added and thoroughly blended, the batch is assayed and, after being brought to specifications, sent to storage. From storage, the mixture is pumped to the filling line.

Filling

The filling line consists of an unscrambler, onto which the cans are dumped from their shipper cases; a 72-head rotary vacuum filler, a level checker; a disk type capper; a code-dating machine and packing stations. For special promotional sales, the cans may be encased in pairs, in a kraft paper package. This is done in a machine installed in the line between the coder and the packers.

In the past, Glim had always been packaged in glass bottles. As expanding production demanded changes in bottle capacity and styling, the packaging line, which was installed in 1948, was modified to accommodate these changes.

When it was decided to package the product in lithographed metal cans, many new problems

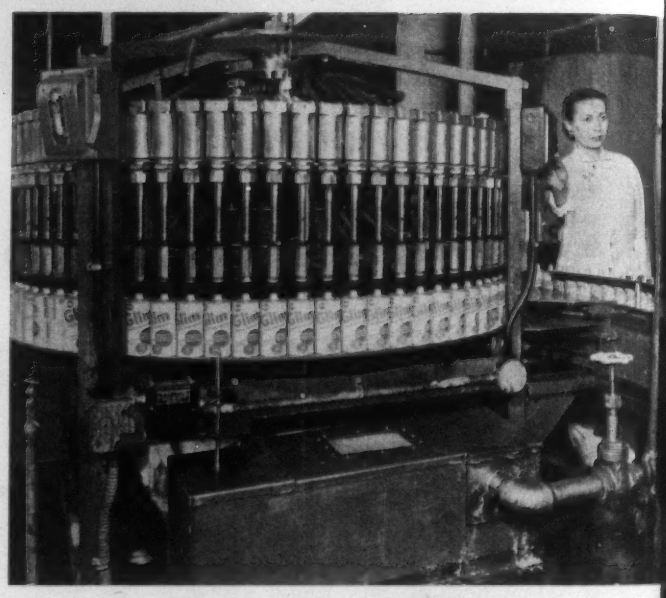


Fig. 3—Empty cans are conveyor fed into 72-head rotary vacuum filler. Operator observes feeding of cans, has just checked reset on filler supply tank pump

Fig. 4—Volume of liquid detergent in each can is checked by a General Electric HYTAFILL unit. X-ray beam is diminutive and all shielding required is included in the design of the unit, so that no radiation problem exists for the user. This fill checker is capable of inspecting within 1/32-inch limits at a maximum speed of 900 cans per minute. Accuracy in practice depends also on the smoothness of the conveyor in presenting the cans for inspection

were encountered which required unique solutions. Breakage and labeling were eliminated; however, filling became an acute headache. A glass bottle was always filled to the beginning of the neck and the customer was assured full measure by a simple glance. With the opaque can, accurate control of the fill became an entirely different matter. An obvious solution was to weigh the cans at some position along the production line. With line speeds in excess of 150 per minute, it was found that only one type of the available check-weighing machines could keep pace.

It was decided to approach this problem from two points of view. First, a statistical study of individual filler spout performance by our Quality Control Group provided an optimum adjustment for each spout. Secondly, the announcement by the General Electric Co. of their new Hytafill liquid-level checking machine appeared to be an obvious solution for eliminating the underfilled can. The Hytafill is capable of inspecting at speeds up to 900 cans per minute and has gained wide acceptance in the food processing and brewing industries. It measures fill without mechanical contact by flashing a narrow X-ray beam though the can and onto a detection cell. If fill is inaccurate, the cell triggers a rejection mechanism which knocks the can off the line into a receptacle. In the brewing industry beer cans are sealed and rejects can be removed from production lines without spillage. However, we realized that the uncapped can presented an entirely different situation.

Working in co-operation with General Electric Co. and with Conveyor Systems, Inc., of Chicago, an efficient and practical rejector was developed. This is basically a dual conveyor having a small air-actuated swinging gate at the inspection point. In operation, an underfilled can passing through the Hytafill's x-ray beam, initiates a rejection signal. This signal opens a conventional solenoid valve, admitting air to the reject gate cylinder. The rejected can is then pushed sidewise onto the parallel reject conveyor. When a sufficient number of rejects accumulate, the filling machine operator examines them, discarding any leaking or damaged cans which have not filled at all and returns the rest to the filler.

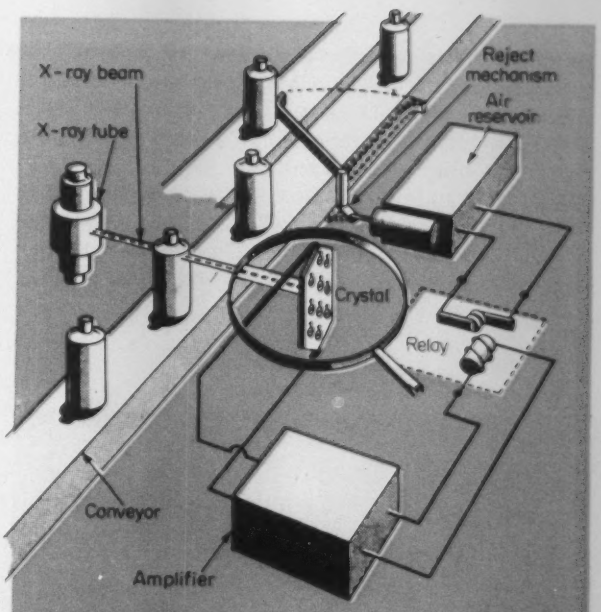
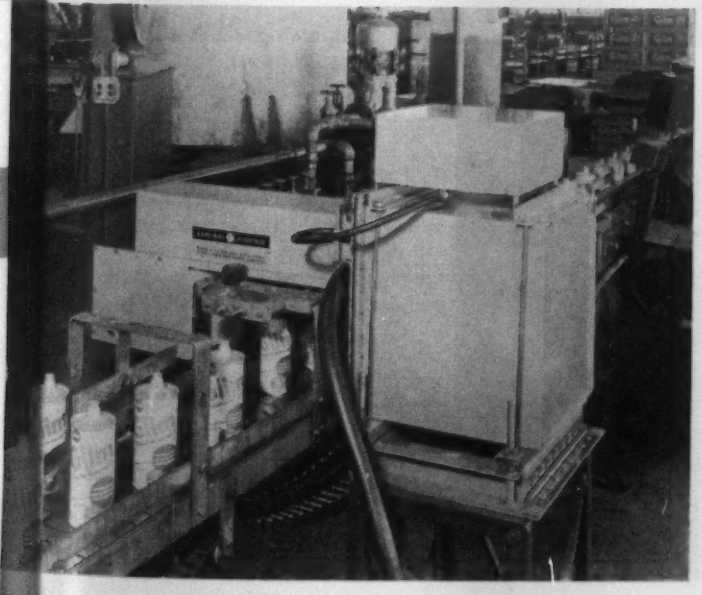


Fig. 5—Schematic diagram of reject system developed in co-operation with General Electric and Conveyor Systems, Inc. Reject signal initiated by underfilled can actuates air operated gate that pushes can sidewise onto reject conveyor

The correctly filled cans next travel to a Resina Automatic Machinery Co. capper, part of the original installation, which was rebuilt to handle cans. This capper is of the spinning disk type. The can, gripped on a moving conveyor, picks up its cap from a magazine fed by a discriminator hopper. The loose cap is then tightened and tensioned by passing between three sets of spinning rubber disks. Each set of disks turns at progressively slower speeds and higher torque, in order to run down, seat and "snug up" the cap. The capping machine operator constantly spot checks the required removal torque since a single loose cap might leak enough Glim to spoil many finished cases.

After capping, the cans pass through an Adolph Gottscho Inc. Markocoder which applies an inked data code to the can bottom just before it goes to the packers.



▶ Packing

At the packing station, girls replace the filled cans in the shipping cartons in which they were

received. This simple procedure of having the cans delivered in their ultimate packages eliminates the storage of knocked down cartons in our plant and the double handling of can packages. As previously mentioned, the cans may be specially packaged for promotional sales. This is accomplished in a unique self-locking Cluster-Pak, developed by the Atlanta Paper Co. The machine which they also have developed to perform this packaging operation is most remarkable in that it has no reciprocating motions and is therefore capable of operating at rates of several hundred cans a minute without vibration. When this machine is not needed, it is simply bypassed by conveyors. The completed case is then automatically sealed and transferred by a trolley conveyor to the warehouse or shipping areas.

This production line represents an example of the evolutionary up-grading of facilities by purchase of new automatic equipment and incorporation of modern developments into an integrated production line. Such is industry's response to the demands of the changing American market.

Fig. 6—View of filling and checking area shows operator at main control panel for filling machine and associated conveyors. As rejects accumulate on conveyor an operator checks them for damage and leaks, rechecks weight and passes cans back to filling machine

Fig. 7—Cans that are filled to the proper level move on to the Resina capping machine. Operator makes spot check for proper seating as cans move on at 150 per minute to the Gottscho Markocoder to be dated on the bottom

Fig. 8—For special promotional sales, cans are packaged by an Atlanta Paper Co. machine which puts two cans in their self-locking Cluster-Pak. Regular runs bypass this machine on conveyor that is behind the machine. Cans are placed in original cartons and sealed for shipment

A pneumatic control system is normally specified for refinery operations. However, in designing a new catalytic reformer unit the decision was made to use an electronic control system. In narrative form, the responsible project engineer describes some pertinent considerations which led to this pioneering decision

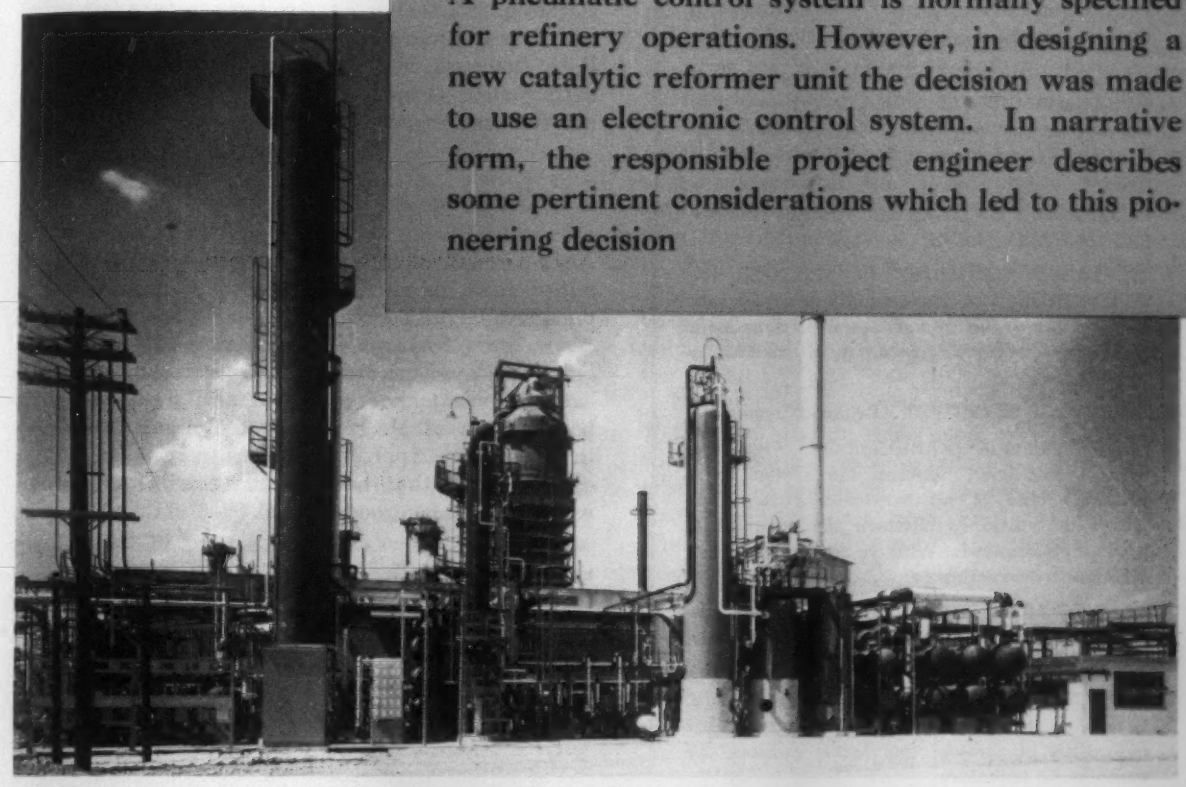


Fig. 1—View of the 8000 barrel per day catalytic reforming unit of the Atlantic Refining Co., Port Arthur, Texas, described in this article. The unit, designed by the H. K. Ferguson Co., is the first of its size to utilize an all-electronic control system

By ROBERT A. DUNCAN
Staff Engineer
The H. K. Ferguson Co. Inc.
Cleveland, Ohio

A CASE FOR ELECTRONICS IN PROCESS CONTROL

WILL IT WORK? The inevitable question when confronting the new or the untried was asked by a group of designers of the H. K. Ferguson Co. in the course of designing an 8000-barrel-per-day catalytic reformer for the Atlantic Refining Co., *Fig.* 1. The question followed a proposal to consider the use of an all-electronic process control system instead of a pneumatic system.

No existing refinery could provide an answer based on experience as there were no large installations in which all instruments and controls were of the electronic type. The problem was further complicated by timing. The proposal, and a request for an investigation, came at a time when the engineering work was about 40 per cent complete. It called not only for making a full scale investigation of the new system, the making of design changes, the rewriting of specifications, and the procuring of instruments (if they were found to be satisfactory), but also for maintaining a tight, previously established schedule. Despite the obvious difficulties, the decision was made to investigate the proposal.

A quick shuffle of our instrument division was made. Electrical engineers were assigned to the group for the first time and a comprehensive program was laid out for the investigation. In making the organizational changes, we were careful to keep our pneumatic instrument experts heading up the proper instrumentation applications and interpreting final results. The electrical people were

Advantages of Electronic Over Pneumatic Control Systems

1. RELIABILITY IN COLD CLIMATE. Air, in a cold climate, unless thoroughly dry, is subject to freezing. Frozen impulse lines lead to loss of process control.
2. ELIMINATION OF COMPLEX TUBING INSTALLATIONS AND RACKS.
3. INCREASED FLEXIBILITY IN MULTIPLE INSTALLATION. With the elimination of air tubing and the use of coded electrical data more complex and rapid cascading of controls is possible.
4. INCREASED SENSITIVITY. Reduced hysteresis.
5. INSTANTANEOUS TRANSMISSION. With electrical transmission between the system components, there is no transmission lag; this means that distance between the components is of no consequence. With a pneumatic system, 1000-foot transmission is approaching the limit.
6. EASE OF MAINTENANCE: Long-life tubes, absence of moving parts and plug-in features, simplify this problem.
7. INTERCHANGEABILITY OF COMPONENTS. Controllers and recorders are interchangeable regardless of service; this factor reduces the spare parts inventory.
8. ELIMINATION OF MOVING PARTS AND ORIFICES. Moving parts have been almost entirely eliminated, and orifices reduced to one.
9. EXCELLENT CONTROL STABILITY. Electronic controls, once calibrated and set, will control until changed, wheras pneumatic controls are subject to environmental fluctuations.

Fig. 2—Considering the possibility of replacing the usual pneumatic control system by an electronic system, the refinery design group decided that this list of possible advantages warranted a full-scale study. As a result of further studies, the electronic system was adopted

to function as full-time consultants and to make an economic survey of installation costs, evaluate types of equipment such as wire and conduit pull boxes, and recommend and plan the electrical installation.

Fortunately, as a part of keeping abreast of new developments, one of our instrument engineers had made a preliminary study of problems associated with an electronic system. Although lacking actual experience, he had collected a modest store of information and with this we were able to get off to a fast start. Our specialists in conventional electrical instrumentation proved valuable during the investigation in evaluating the new electronic type of controls.

We found that at that time only two firms in the United States had made sufficient progress in this new field to have the required types of instruments in actual production. Both had developed electronic control loops for temperature, pressure and flow but had not made any major installations. Both, however, had placed control loops under test with various firms for periods up to one year, with excellent reports received.

▶ Choosing A System

As a result of initial investigations it was determined that an electronic system is superior to a pneumatic system for the reasons shown in *Fig.* 2. Since these features were common to both of the electronic systems studied, it was decided that the actual performance of pneumatic as opposed to both makes of electronic control loops should be investigated. Appropriate tests were made. They convinced us that both of the electronic systems were at least as good as had been claimed.

The next step was to make a final choice between the two competing electronic systems. The system we selected was superior, in our opinion, for these reasons: (1) Fewer tubes (five per loop vs. nine); (2) better workmanship; (3) one million-hour red-base tubes operating at 10 per cent capacity; (4) simpler transmitters (no tubes); and (5) better general design features.

Our findings and recommendations were presented to and discussed with our client. His engineers were in accord and we were given an enthusiastic go-ahead. Specifications were written

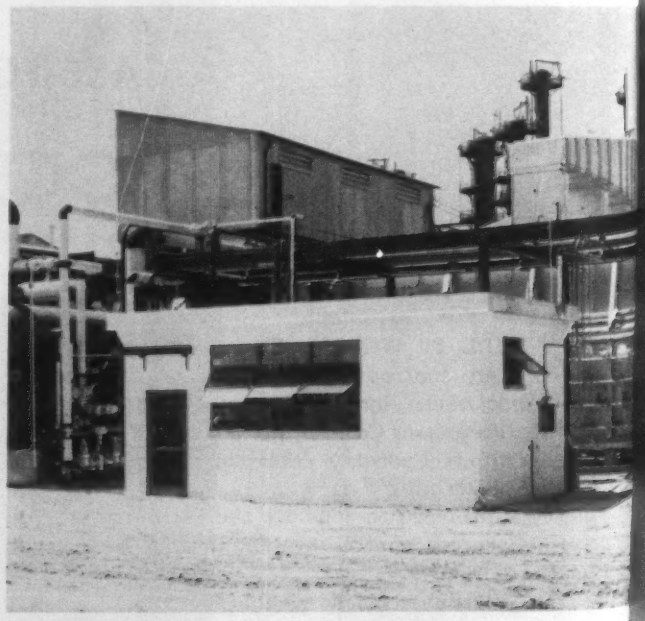


Fig. 3—Control room, housing the control console, is classified as a non-hazardous location. This classification permitted the use of recorders, controllers, switches, etc. in the console which are not explosion-proof. The result is a simpler and more economical installation

and approved, and the instruments were placed on order.

At this stage, working closely with the owner, Ferguson engineers were making a study of the wiring installation. All of the power and lighting installations in the plant were to be installed as prescribed by the *National Electric Code*, Section 500, "Hazardous Locations." It had to be explosion-proof. However, we felt that the requirements of the code could be partially modified in the case of the instrument wiring and the owner agreed. We then checked the project for explosion hazards. The control house was designated as nonhazardous and this simplified the console design appreciably, *Fig.* 3. The control components, i.e., recorders, controllers and transfer switches, which were to be incorporated in the console, were not explosion-proof and it would have been a bit of a task to have met this requirement.

We next considered the wiring outside of the control room in the plant area. Initially, we were of the opinion that all of this would have to be explosion-proof. This meant that we would have to run a large main conduit from one end of the plant to the other, and take off our services at connector boxes located at several centralized points. This would be expensive construction. The owner, however, took a liberal stand. As the routing of all the wiring was to be on an outside pipe rack at elevation of 18 ft with adequate air circulation, it was difficult to visualize any hazard. It was suggested, therefore, that we use a 4 by 6-inch covered galvanized trough. All leads from the transmitter and to the transducer, however, were to be in explosion-proof conduit. This reduced costs appreciably. Such an arrangement, of course, would not be considered in an enclosed plant where there would be the slightest possibility of explosive vapors being present.

Installation of System

Based upon the nonhazardous standard, the console was then designed and assembled, *Fig.* 4. Incorporated in the design were arrangements whereby all external wiring would be tied into connector blocks, minimizing field labor. The console proper was delivered to the site completely assembled and wired, with only final calibration to be accomplished in the field. As no previous installations had been made, no material was available to use as a guide for the construction drawings and because our construction people were obviously not experienced in this relatively complex and entirely new type of installation, we gave considerable study to the type of drawings that should be provided. While the concept is intricate, it developed later that elaborate detailing was not needed, and the involved installation was made with no problems being raised.

The complete electrical and electronic systems of this installation were made by electricians. Included were the outside connections to the transmitters and power relays (previously installed by mechanics), conduit runs, and wire installations. The electricians also made the connections within the instrument console and checked out the circuits which they had installed. The instrument people then took over and rechecked the circuits and calibrated the instruments.

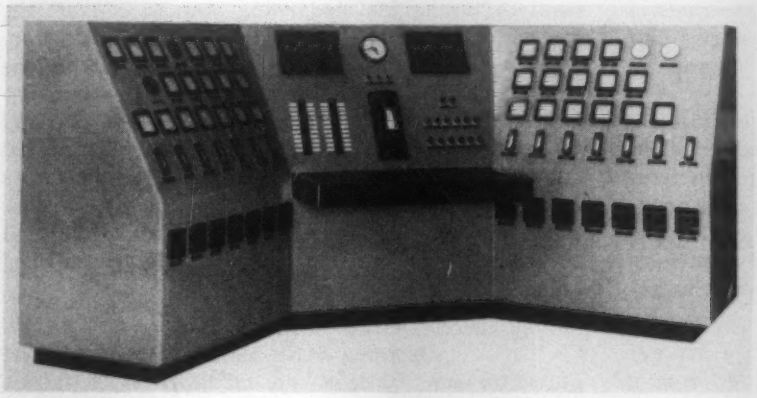


Fig. 4—Console was shipped to the plant's site as a unit completely assembled and wired. External wiring is tied into the console through connector blocks—a feature which expedited field installation

It might be well to point out that one of the plant instrument engineers underwent a training period at the instrument factory previous to start-up. This, of course, would be a normal precaution in any case. It is apparent from the circuits in the instruments that anyone with a knowledge of radio would acquire a ready grasp of the principles. In addition, the interchangeability of components would alleviate any fears as to maintenance. Therefore, with one trained electronic instrument man, and a reasonable supply of spare parts, we felt no great apprehension on start-up day.

On the day selected, naphtha was charged to the unit at 4 p.m. The normal points for the control of the process were set on the console. Within four hours the unit was "on stream." The electronic instruments controlled perfectly from the start. Plant operators and instrument men who had initially been skeptical of the new method

were soon ardent boosters. Performance has been such that little or no trouble has been encountered or replacement made in the period the unit has been in operation.

Improved Operations

The specific process under discussion is essentially catalytic cracking and isomerization at relatively high pressures and temperatures (975 F and 875 psig). One of the peculiarities of the process is the absolute necessity of maintaining precise pressure and temperature control in order to insure a uniform end product.

As a rule, the product is 93-octane gasoline, but if the temperature in the processing plant runs too high, 94-octane gasoline is produced. The higher the octane material, the higher the gas loss. On the other hand, if the octane is too low, tetraethyl lead must be added to bring it up to standard. Obviously, it is cheaper to make correct octane all the time.

Such uniformity is now possible, since the electronic control system holds process variables within extremely narrow limits. For example, a temperature of 975 F might be reached before a pneumatic control system would shut off. It could then drop to 965 F before the control opened. By contrast, electronics holds a narrower margin on the required 975 F setting, and maintains the range between 976 and 974F. The same margin of control can also be held on pressure and flow settings.

How the narrower margin of control is achieved with electronics can be illustrated by reference to the action of the temperature controllers. Many temperature controllers today incorporate a derivative function based on the rate of error change to provide more accurate control. A rapid increase in error between measured process variable and desired process variable makes a much greater correction to the control valve than a slow increase.

However, most temperature controller designs of the thermocouple type have not permitted optimum use of the derivative function. There is usually a mechanical means of balancing the potentiometer circuit that converts the electrical impulse to a pneumatic control impulse. The mechanical balancing mechanism does not detect a slow change in process temperature until the degree of change is fairly large. When the mechanical system suddenly tries to catch up, the derivative unit senses a rapid rate of change and makes a larger correction to the valve. This action has a tendency to upset the plant.

An electronic control system requires no intermediate mechanical balancing step to convert the electrical thermocouple signal to a control function. Thus, we have a more accurate picture of the true rate of change in the process. On this particular installation, the derivative settings were adjusted to rates that were never before thought practical on similar applications. Minute temperature changes are compensated before they become noticeable on the recorder with the result that the charts look as if a straight line had been ruled on them.

COMPARISON OF COSTS OF PNEUMATIC AND ELECTRONIC CONTROL SYSTEMS

	Pneumatic System	Electronic System
Cost of Instruments	50 x $678/instrument $33,900	50 x $880/instrument $44,000
Air System (includes compressor, drier, controls, etc)	50 x $185/loop 9,250	Estimated 1/3 of pneumatic system cost 3083
Material Installation	1/4-in tubing 50 x 200 ft x $0.65/ft 6,500	Galvanized trough 90 ft x $2.00/ft ..... 180 1/2-in conduit 50 x 20 ft x $0.50/ft ..... 500 4-wire leads 50 x 100 ft x $0.55/ft ..... 2750 2-wire leads 50 x 100 ft x $0.45/ft ..... 2250 Contingencies ..... 300 total 5980
Total Costs	Pneumatics $49,650	Electronics $53,063

Fig. 5—For comparison purposes, assume installation involving 50 control loops for flow recording control—the least favorable to electronic moneywise. Each control loop will involve 100-foot run from transmitter to console and 100-foot run back to control valve. Console and control point equipment costs considered to be equal. As shown, the cost of an electronic system is 6 to 7 per cent greater than a comparable pneumatic system. However, the long-range replacement cost of pneumatic instrument tubing, which has a life expectancy of five years, will overshadow the small initial price advantage of the pneumatic system

Costs Comparison

From the owner's viewpoint, the installation is improving the quality of his product and reducing his operating and maintenance costs. In short, it is a money-maker. Such a statement is intentionally a broad one. What about first costs—do they compare favorably with pneumatics? If not, will reduced installation and maintenance costs bring the electronics down to the point where they may be considered competitive. We feel that the answer is a definite "Yes." However, this will depend on the size of the installation. If only a few control circuits are to be installed, the electronic system prices itself out of the market. The price increment diminishes in favor of the electronic as the size of the installation grows. This can be illustrated by considering a hypothetical installation, *Fig.* 5. As indicated, the electronic system is only 6 to 7 per cent greater in cost. Where, then, is the pay out? There are the savings resulting from better quality control, less downtime, and lower maintenance costs. For instance, the highly corrosive atmosphere of many process plants allows us to assume a life expectancy of five years for instrument tubing. For the hypothetical case, each replacement cost would amount to $6500. However, the wire may be assumed as permanent, the conduit life being assumed as ten years. Conduit replacement costs would then be only $680 as opposed to $13,000 over a ten-year period. From a long-range view, this feature in itself outweighs the first cost increment.

In conclusion, we believe that electronic controls are to play a steadily increasing part in process plants. With electronic controls, it is possible to include many recently developed systems, which are of interest to the process industries, particularly in petroleum and petrochemicals.

With these combination systems, the following applications (among others) have been developed: Radio transmission of operator data; radio transmission of plant control; multiple data single wire transmission of signals; print out, whereby, all plant data is automatically logged by electric typewriters at predetermined intervals; information centers, in which the data may be received, stored and evaluated at central points at great distances from the operating plants; and process programming wherein all steps from initial to end product may be automatically established, controlled and logged.

It must also be considered that the future holds every indication for further refinement and cost reductions. Several of the major pneumatic manufacturers are conducting aggressive research programs on electronic controls. Certainly we may expect to see prices reduced appreciably, possibly below that of pneumatic equipment. This forecast is supported by current prices of radio and television sets as opposed to those of a few years ago. The manufacturing techniques in the electronic instrument field are essentially the same. Quantity production, printed circuits and the use of transducers will simplify circuit design, reduce instrument sizes and effect pertinent cost reductions.

THE AUTHOR

ROBERT A. DUNCAN has had many years experience in the design of petroleum and chemical process facilities. In his present position as staff engineer with the H. K. Ferguson Co., he specializes in petroleum products and prior to this he has been associated with the Shell Development Co. and the Associated Oil Co.

In describing the reaction of refinery authorities who have had an opportunity to inspect this new installation, Mr. Duncan reports that in general opinions are favorable, but that in no sense does it spell the doom of pneumatic instrumentation. The predominant reaction of authorities indicates a reappraisal of thinking with an eye toward the increased future use of electronics in refinery installations.

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By V. N. HANSFORD
President
Morley Machinery Corp
Rochester, N. Y

RESULT OF PRACTICAL DESIGN . . .

PROJECTILES WELDED AUTOMATICALLY

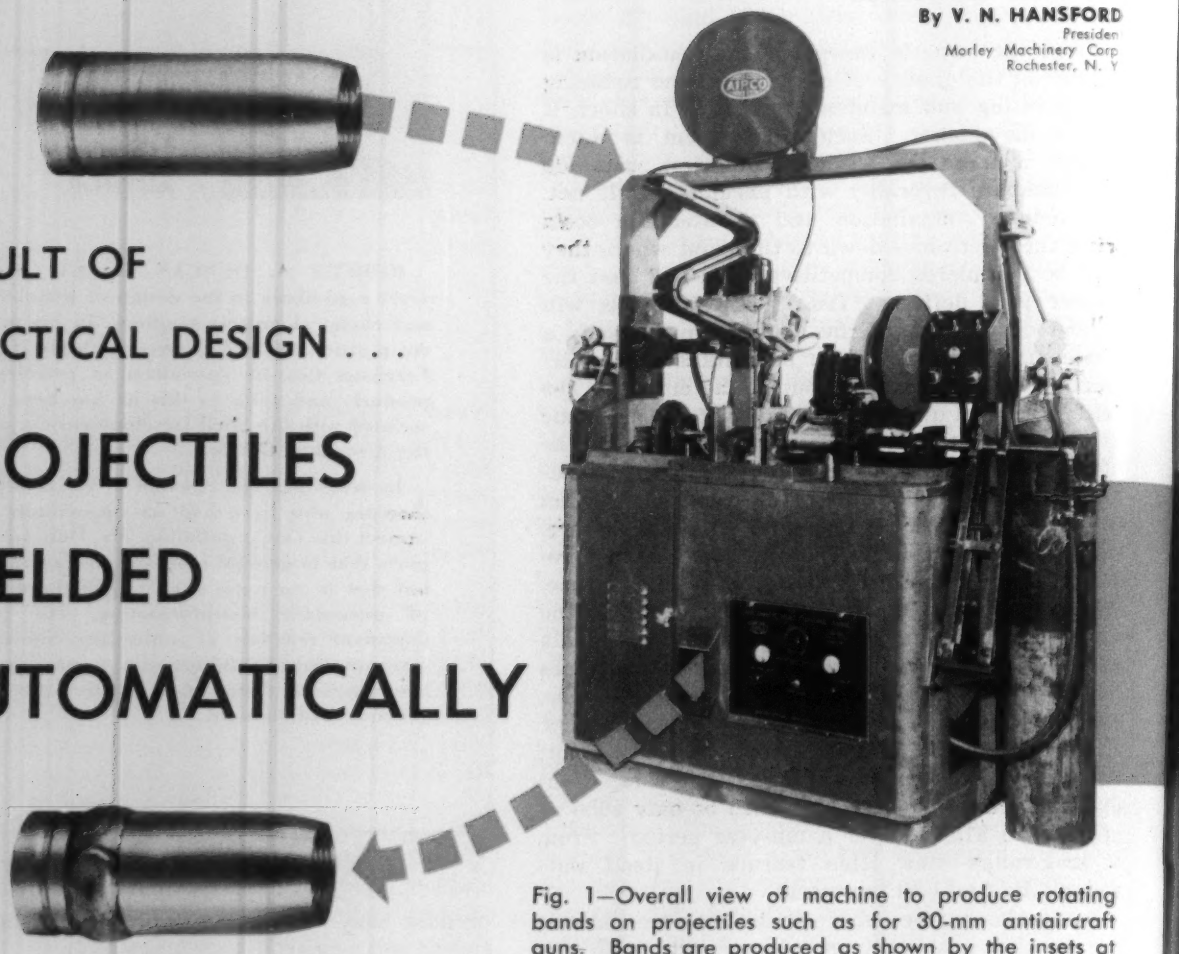


Fig. 1—Overall view of machine to produce rotating bands on projectiles such as for 30-mm antiaircraft guns. Bands are produced as shown by the insets at a rate of about six pieces per minute

Degree of attainment of desirable increases in productivity will depend on application to products and equipment of practical principles of design for automatic production. The example of product and machine features described here illustrate developments in one modern competitive industry

AMMUNITION for artillery and small arms has been purchased by the United States Government from private manufacturers for many years. Back in World War I days these manufacturers were considering ways to "automate" and step up production. Between World Wars I and II considerable thought was given to methods of projectile production through Ordnance Committee work. With actual practice during World War II greater advances in manufacture of projectiles were made, but the requirement of increased production was still the prime consideration.

Since World War II the manufacture of ammunition has been a highly competitive business. Many private concerns are interested in the few contracts available and the greatest emphasis is now on economical volume production. Changes in the designs of shells used in U. S. guns have also been made. Thinner projectile walls have been specified, and increased consideration has been given to conservation of strategic materials.

One specific development due to these factors has been in the design and method of installing rotating bands.

Basic Projectile Component

The rotating band on a projectile is a soft band of copper or gilding metal securely fixed on the OD of the projectile. As its name implies, this band serves to impart rotation to the projectile due to the rifling of the gun barrel which the band contacts closely. The band also serves as a seal between the projectile and the barrel to more effectively use the propulsive force of the gases generated in firing.

In the past, rotating bands have been separate bands of soft material which were pressed into a groove and prevented from rotating on the projectile by mechanical means such as knurled ribs in the base of the groove. This type of rotating band is still predominant, but a newer type of band produced by overlay welding and subsequent machining is gaining in popularity. This newer method is especially useful where the walls are so thin that they cannot resist the pressures necessary to assemble conventional rotating bands. The welding method also can utilize such materials as iron to conserve copper when necessary.

Fast efficient means to deposit weld metal for a band has been of real interest in the competitive post-war market, and this interest has resulted in the design of special machines for this purpose by Morley Machinery Corp. of Rochester, N. Y. One of these automatic machines is shown in *Fig.* 1 and produces the welded band shown by the *Before* and *After* illustrations of the projectile.

The machine functions automatically, and one operator can supervise two or three machines, loading their supply magazines and disposing of welded parts. Parts handling can also be done automatically. Machines like the one shown will produce welded rotating bands at the rate of approximately six per minute. The bands are deposited by overlay welding. An inert-gas-shielded arc is employed with continuously consumed electrode fed in wire form from a reel. An auxiliary nonelectrode (cold) wire is also fed into the arc to increase the volume of deposit.

Briefly, the machine consists of automatic means to feed, chuck, and rotate projectiles while depositing a soft band—with provision for cooling and discharge.

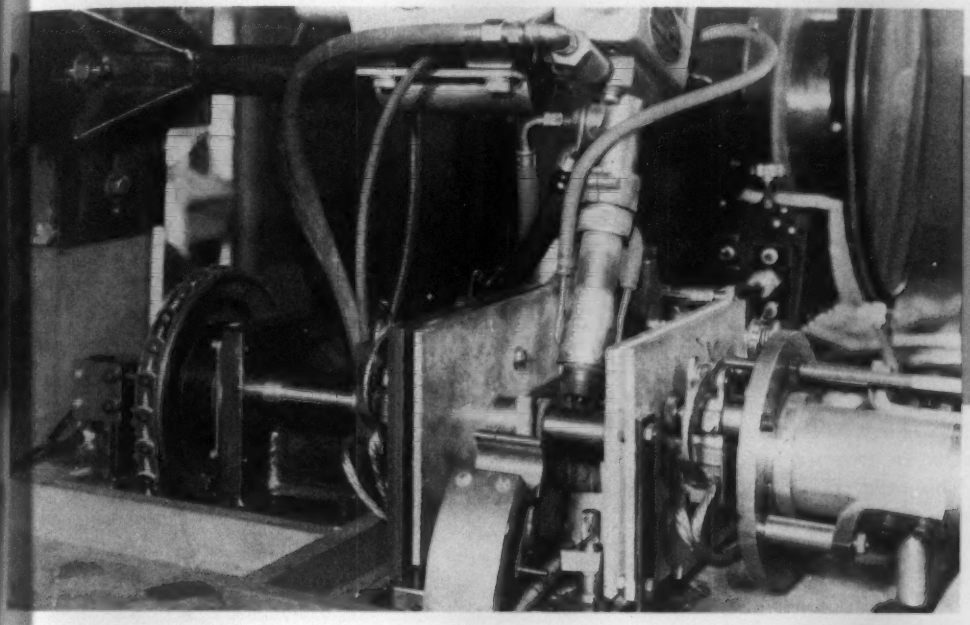


Fig. 2—Close-up of machine shows a projectile in position under the welding head ready for welding. The supply magazine was removed for better visibility in this picture

Machine Loading

One projectile at a time is taken from the magazine by the loader, *Fig.* 2, and presented between chucking adapters. The aluminum loader arm is made in two parts. The top is held forward against the bottom—which is also a cam follower—by means of a spring. This construction prevents harm to the loader arm if a projectile sticks in an adapter. The clamping jaw of the loader nudges the part to make it drop when a workpiece sticks in an adapter. After the shell is clamped by forward movement of the tailstock, the loader jaw is opened by a cam and the arm moves back under the magazine. When the loading arm moves forward to present a piece, the other parts in the magazine are held up by the tail of the loader arm. As the arm returns to its rest position the jaw is cammed open again and the next part drops into position. Cycle time for dropping a welded piece and loading a new one is one second. This timing

is fixed and does not vary with changes in spindle speed.

Movements of the loading mechanism are generated by a loading cam. This cam is driven from a gear reduction motor through a solenoid-controlled single-revolution clutch. This gear reduction motor is the prime mover in the machine and also rotates the drive spindle. The clutch driving the loading cam is of overriding design and a friction brake is incorporated which rides on the cam barrel and retards the cam when the loader arm cam follower is on the down stroke.

Loader in Action

When the loading cam starts revolving, a radial land passes the loader follower and no movement of the loader arm takes place. This allows ½ second for cooling of the projectile; a necessary delay, since the loading cam starts revolving immediately when welding stops. The end of the weld is still liquid at the time the welding stops and would spill off if the part were dropped before solidification of the weld. This also is the controlling factor in determining direction of shell rotation and the positions of the welding head and auxiliary feeder.

Workpieces are chucked and rotated between adapters. The adapter threaded on the drive spindle or headstock end of the machine has a knurled surface on its tapered mouth. The base of the projectile is seated by spring pressure in this knurled mouth. Elimination of slip between these surfaces is important to obtain complete bands since timing of the welding cycle is based on spindle rotation. The spindle is driven from the prime mover through a variable speed transmission and an electric clutch which is controlled by a sequence timer.

Interlocking control is provided on the spindle by a spring-loaded rod projecting slightly through the chucking adapter. When a part is properly chucked, the rod is depressed, closing a limit switch, LS-1 in *Figs.* 3 and 4. Until this switch is closed, no flow of welding current or coolant takes place. A connection to the driving adapter for welding current is provided by a copper slip ring and two carbon brushes. A Transite plate mounted on the machine fits around the spindle and protects it from weld splatter.

Tailstock of the machine is a form of live center. It has an adapter threaded into a tubular shaft which rotates in bearings inside an aluminum housing. The housing does not rotate but does move linearly toward and away from the drive spindle to chuck and unchuck workpieces. The housing is supported by a shaft which slides in bearings

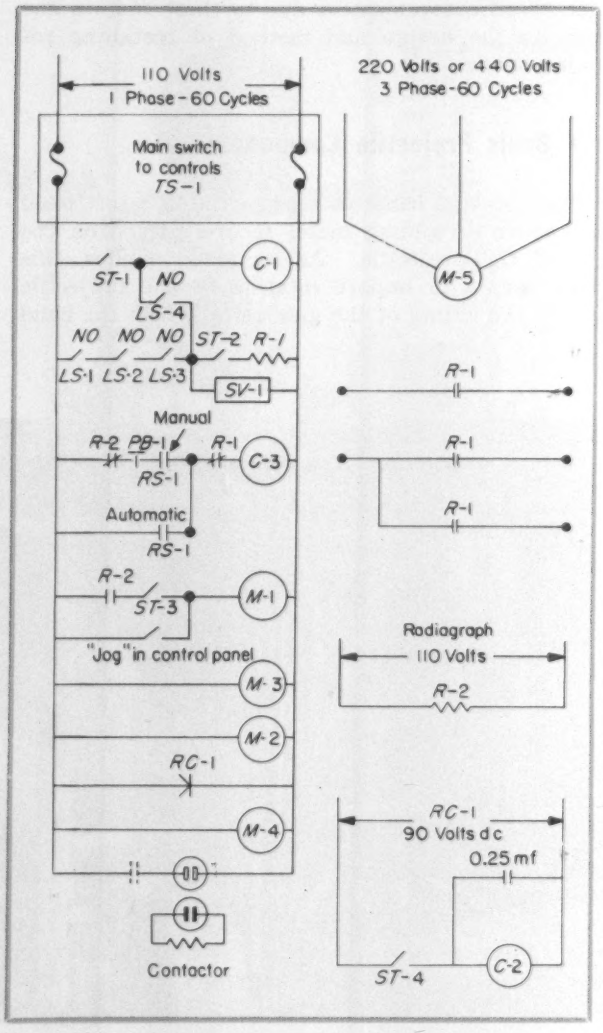


Fig. 3—Major components of the machine and its controls are indicated by the diagrams and the key included

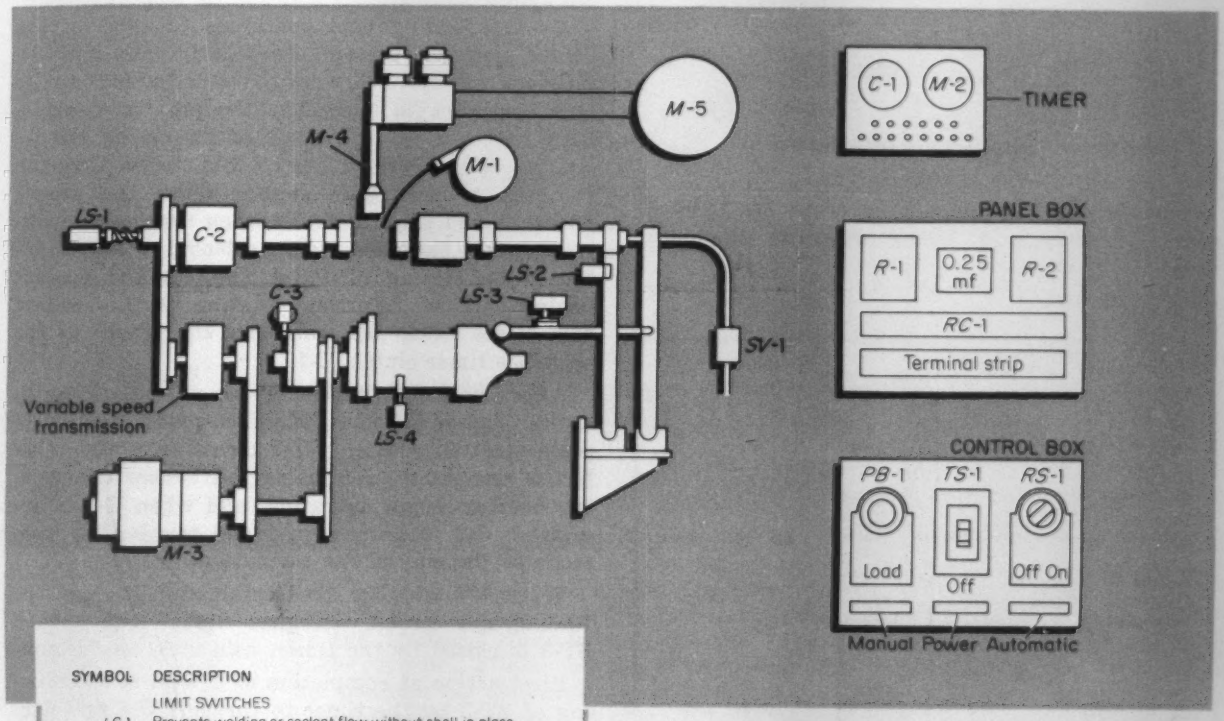
mounted on the machine base. The housing assembly is drawn toward the headstock by springs under the adjustable control of a hydro-check and is cammed away from the headstock by a cam track fastened to the loading cam. The open end of the tubular adapter shaft empties coolant into a chamber in the end of the housing farthest from the adapter. This chamber drains out to a sewer connection through the base of the machine as waste disposal.

Controlled Cooling

Coolant is brought inside the workpiece by a coolant tube with a removable spray tip. This tube slides inside the housing support shaft and through the adapter shaft and adapter so that the coolant spray strikes the ID of the projectile directly inside the band area. The coolant tube is inserted into the part by a spring linkage to the housing assembly. It is cammed out of the shell and then

on away from the headstock with the housing assembly by the same cam arm that moves the housing. Since the coolant tube is extended beyond the adapter by spring force, the tube is not damaged if the base of a projectile should be toward the tailstock. The spring will merely be extended, and coolant will not flow because the control rod through the headstock will not be depressed by the open end of the workpiece, leaving limit switch LS-1 *Open*.

A Klosure seal manufactured by the Garlock Packing Co. keeps coolant from entering the bearings between the adapter shaft and the housing while an O-ring is used to prevent coolant flow between the housing support shaft and the coolant tube. Movement of the housing assembly toward the headstock is positively limited by a collar on the housing support shaft which seats against the support pillow block. This limitation prevents injury to the loader arm in case the loading mechanism is operated with no parts in the magazine. A second Transite shield mounted on the machine base and fitting around the tailstock adapter shaft protects the housing assembly from weld splatter.



SYMBOL	DESCRIPTION
	LIMIT SWITCHES
LS-1	Prevents welding or coolant flow without shell in place
LS-2	Prevents welding or coolant flow without tailstock forward
LS-3	Prevents welding or coolant flow without coolant tube forward
LS-4	On loading cam - starts timer
	RELAYS
R-1	Turns on welding head
R-2	Turns on cold wire feed
	PUSHBUTTON
PB-1	Manual loading cycle
	ROTARY SWITCH
RS-1	Automatic - manual
	SEQUENCE TIMER
ST-1	Holding contact for timer clutch
ST-2	Welding head control
ST-3	Cold wire control
ST-4	Spindle control
	MOTORS
M-1	Auxiliary cold wire feed
M-2	Timer
M-3	Prime mover
M-4	Welding head
M-5	Generator
	CLUTCHES
C-1	Timer
C-2	Spindle
C-3	Loading cam (single-revolution clutch)
	RECTIFIER
RC-1	Produces dc for spindle clutch
	TOGGLE SWITCH
TS-1	Main control switch
	SOLENOID VALVE
SV-1	Coolant shut-off

Fig. 4—Outline of the circuitry used to control the building of rotating bands by welding

As on the headstock end, a copper ring mounted on the adapter spindle and associated carbon brushes provide an electrical connection for welding current.

Deposition of the band metal is accomplished by the use of welding equipment consisting of: An Air Reduction Co. Inc. Aircomatic head with dynamic brake, low and over-voltage control; an Air Reduction Co. Inc. auxiliary cold wire feeder; argon and oxygen supplies with pressure regulators, mixing flow meters and manifold proportioners; and a 600-amp motor-generator with contactor.

Mounting of the welding head allows adjustment in three dimensions. The electrode supply reel is mounted overhead to give a short straight run to the welding head. The welding wire feed is operated through a differential mechanism and controls which maintain a constant arc voltage. A

dynamic brake is incorporated to stop the wire quickly at the end of a weld. The cold wire feeder, with wire reel attached, is mounted at the rear of the machine. It is driven directly by a small ac motor. Since this reel can coast, the motor is turned off by the timer slightly before the end of the weld to prevent the cold wire from adhering to the welded band. The auxiliary feeder can be jogged by means of a switch on the Aircomatic control panel.

Electrical Sequence Controls

Controls on this machine operate on 110-volt single phase ac. A wiring diagram, schematic machine diagram, loading cam chart and sequence timer chart are shown in *Figs.* 3, 4 and 5. By reference to these sketches the control operations may be followed. Assuming that a projectile has just been welded and the main welding head turned off, the control actions will proceed in the following sequence.

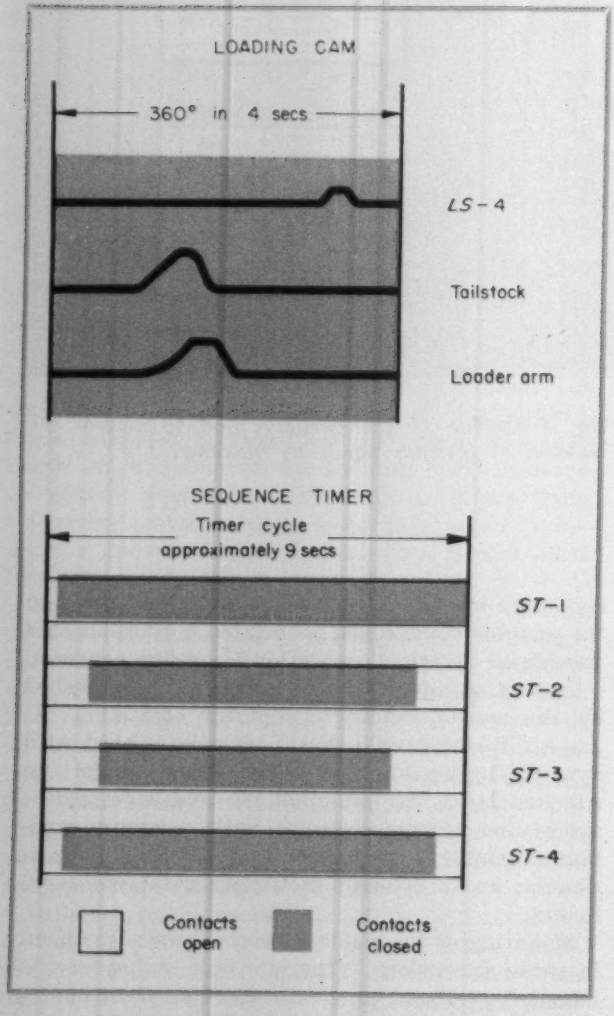


Fig. 5—Relative sequence of control actions generated by the loading cam and sequence timer are illustrated by these diagrams

Clutch C-3 will be energized and the loading cam will start a revolution. The coolant tube will be withdrawn and the tailstock will be cammed away from the headstock, opening limit switches LS-2 and LS-3. The projectile will fall into the disposal chute. Limit switch LS-1 is opened when its control rod is released by the unchucking of the workpiece.

As the loading cam continues to revolve, the loader arm will present a new workpiece and the tailstock will move forward to chuck the part as the cam continues to turn. As the part is clamped, LS-1 is closed by depression of its control rod by the base of the projectile; LS-2 is closed when the tailstock housing and adapter reach the proper position; and LS-3 is closed when the coolant tube is properly extended. The solenoid valve is actuated by closing of these contacts and coolant begins to flow. Further rotation of the loading cam closes LS-4, and completes the circuit to the sequence timer clutch, C-1.

After the timer starts, ST-4 is closed. This energizes clutch C-2 and the drive spindle and workpiece start to rotate. ST-2 closes next and relay R-1 is energized. Actuating R-1 causes the welding head to begin operating, and when R-1 is energized, C-3 is de-energized and the loading cam stops at the end of one revolution.

When the welding head establishes its arc, the Radiagraph circuit energizes relay R-2. When ST-3 is closed by the timer, cold wire feed begins.

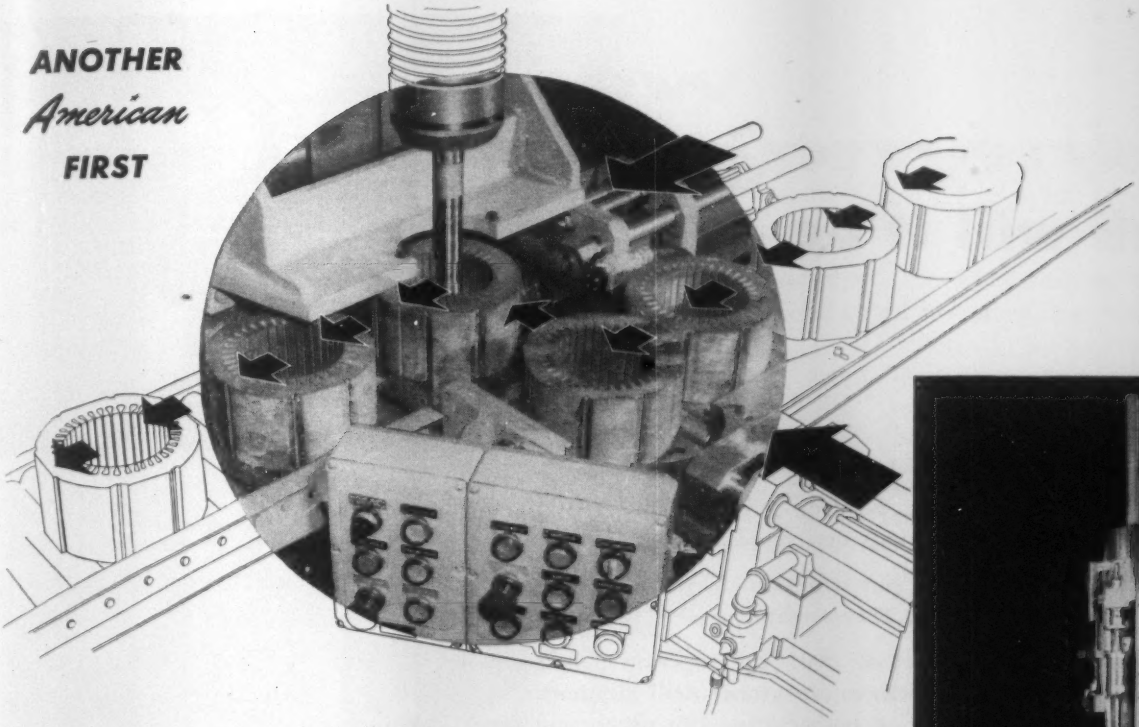
First action at completion of a weld is the opening of ST-3 by the timer to turn off the cold wire feed slightly before the end of the weld. Next the timer opens ST-2, thus de-energizing R-1. This action turns off the welding head and also energizes C-3 to start the loading cam for another revolution.

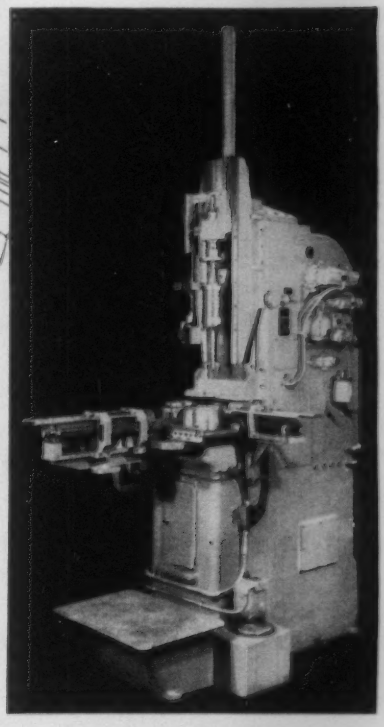
Finally the timer breaks holding contact ST-1 to the timer clutch, C-1, and the timer is stopped and reset for its next cycle.

Automatic sequencing as outlined occurs with the rotary switch on *Automatic*. If this switch is moved to *Manual*, pushbutton PB-1 must be pressed after each part is welded since the entire manually controlled operation will come to a stop after each welding cycle.

Machines such as the one described here mark specifically one further step toward more automatic production of modern shells with welded rotating bands. Of more general interest and value are the broad possibilities for application of some of the design principles of this machine and its product to automatic machines and products in other industries. Realization of bright visions for the future and dreams of manufacturing miracles will require concrete practical expression in better design of more products and machines for automatic production.

ANOTHER
American
FIRST





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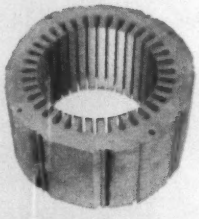

Installed in a conveyor line, this American 3-way broaching machine with a hydraulic broach retriever and electrical controls, broaches the I.D. of stator parts in a 20 second cycle. Parts coming into the machine are automatically shuttled into position, broached, and then discharged back on the conveyor line. Interchangeable broach arbors and broach shells make it possible to broach several different parts of similar size.

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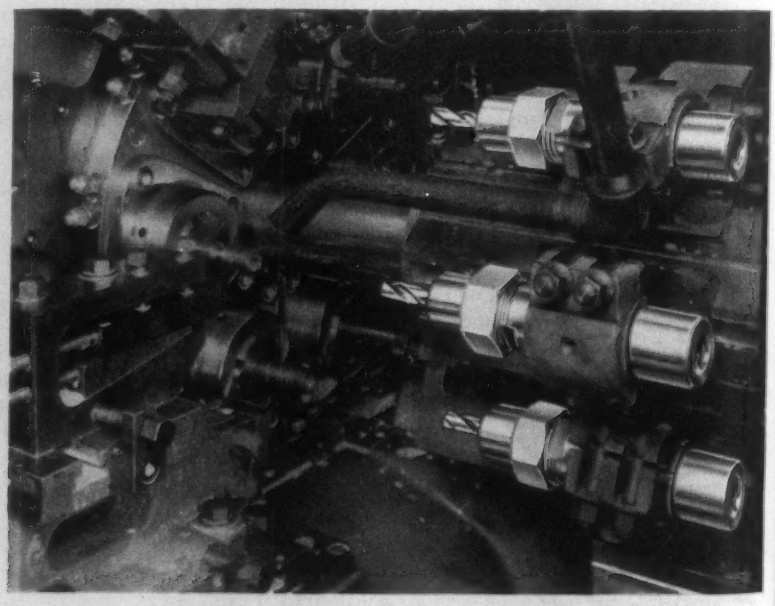

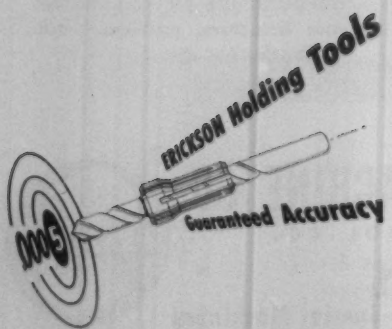

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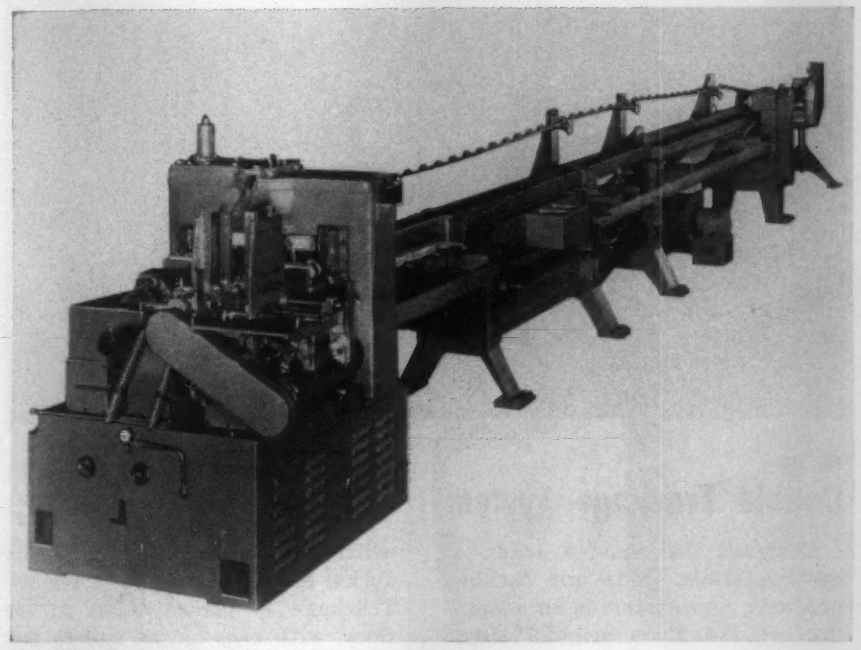

No. 1—

High-Speed Can Production

Designed to produce 400 to 450 cans per minute, new high-speed bodymaker features compact design. Work table is equipped with knurling, notching, edging and prefluxing attachments, yet has no idle station. Single-station, double-action edger is driven by a short eccentric which contributes to the speed. Forming horn is stationary, permitting perfect alignment with solder attachment. Cam-actuated overhead blank lock prevents movement in forming stations and assures well rounded can. Notching chips are removed by compressed air to prevent their jamming the carbide dies or getting into the machinery. Bodymaker is furnished with automatic controls, limit switches and control panel. Built for sustained, automatic operation at high speeds, machine handles cans ranging from 2⅜ to 5⅛ inches in height and from 2 1/16 to 4¼ inches in diameter. Solder attachment is three-station, water-cooled, outside horse type, with an overhead can carrier chain which is provided with guards and driven by its own motor. **E. W. Bliss Co.**, 1375 Raff Rd., S.W., Canton, O.

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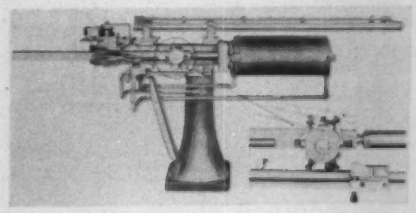

No. 2—

Tube Bender

Automatic turret attachment on tube bending machine speeds and simplifies operation and increases production. Turret can be set to make a number of different angle-bends automatically without any manual manipulation. Operator sets it the same as a manual turret, but on return stroke of the rack, a ratchet engages the index finger and advances the turret automatically to the next position. Turns are adjustable longitudinally on the rack to accommodate different setups. Index finger unit is demountable for manual operation when desired. Machine handles round tubing, light angles, channels and solid bars. **Paul Machine Tool Co.**, 4600 S. Kedzie, Chicago 32, Ill.

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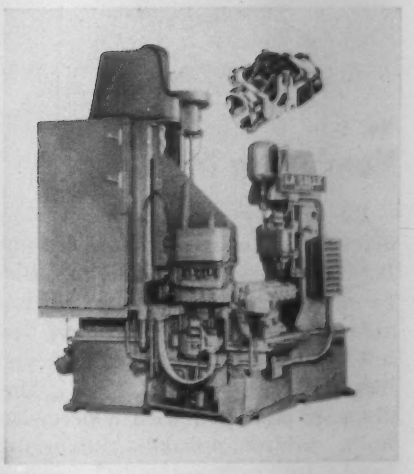

No. 3—

Brake-Cylinder Machine

Five-station, dial type machine drills, chamfers, spot faces, hollow mills and taps brake cylinders. Machine processes four brake cylinders at one time, with automatic clamping and unclamping, and produces 1028 brake cylinders per hour at 100 per cent efficiency. Thrust cylinder is mounted in front of the ways, in the center of thrust load. An electric motor is mounted

on column of machine, and the head is driven through a splined shaft which reduces overhang on the ways, resulting in less wear. Rigidity and accuracy are maintained by using twice the head overhang as length of braking on the ways. Each head has an individual circulating lubrication pump. Eight-spindle head works from the bottom upward, saving an additional operation. Head is hydraulically operated and electrically controlled, with a controlled feed and an adjustable positive stop. It is mounted on hardened and ground guide bars, and locates in the fixture on each cycle. Head is driven by a hydraulic motor with a 5 hp output. **LaSalle Tool Inc.,** 3840 E. Outer Dr., Detroit 34, Mich.

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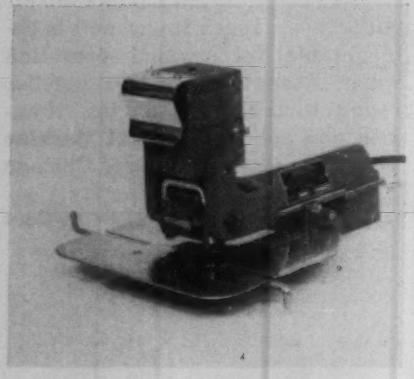
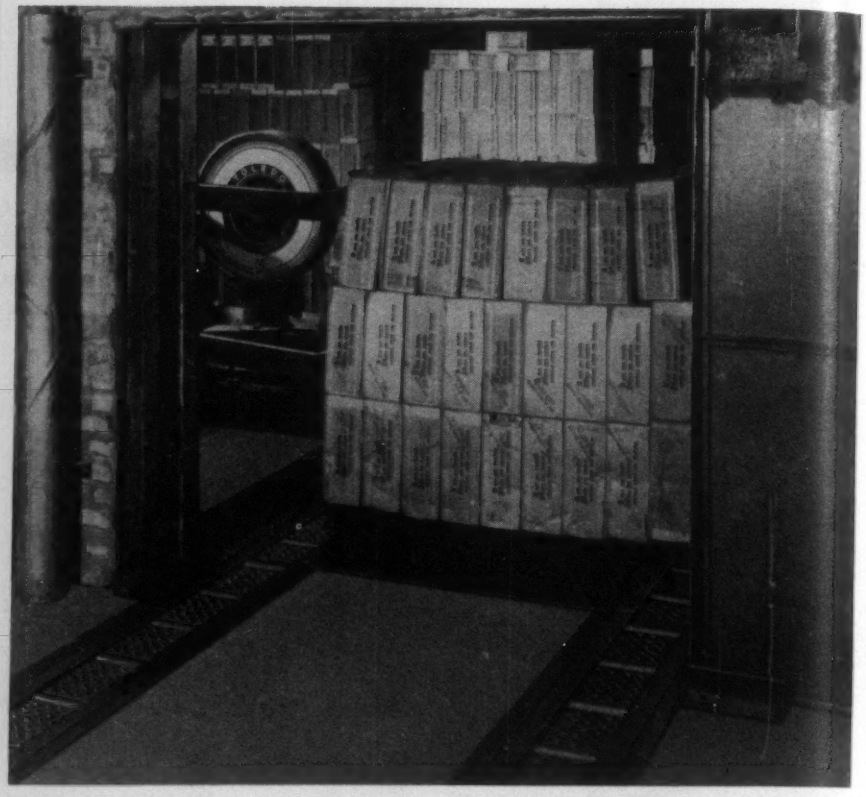


No. 4—

Numbering Machine

Electrically operated numbering machine automatically prints numbers on cards, labels, carbon forms, etc. It features an adjustable work positioning means for left, right and rear positions and has a 6-inch throat depth. Machine is equipped with a precision built interchangeable numbering head to automatically number from 1 to 999,999. It is easily set for consecutive, duplicate or repeat action by shifting action lever into the desired position. Roman or Gothic figures can be furnished in size 3/32, 9/64 or 3/16-inch. Machine has an independent safety shut off switch and is operated by depressing the actuating plate at the front of the machine. **Roberts Numbering Machine Co.,** 700 Jamaica Ave., Brooklyn, N. Y.

Circle No. 4 on Reply Card



No. 5—

Double Trackage System

Designed for moving loads of raw materials, parts and finished products, new system is an adaptation of the Epco original single trackage system which has been used in paper mills and corrugated box plants to handle heavy paper rolls. Any kind of a load which bridges two parallel rows of trackage can be carried on a skid with the double trackage system. The legs of the skids are actually runners, one on each side, which slide over the rollers of the trackage which can be installed into loading docks, bridges, scales or elevators. Trackage is placed flush in the floor, with tops of the rollers just above heavy steel safety treads. Turntables are used to change direction.

System is said to facilitate movement of heavily loaded skids from machine to machine or along assembly lines by one man. **Engineering Products Co. Inc.,** 122 S. Michigan Ave., Chicago 3, Ill.

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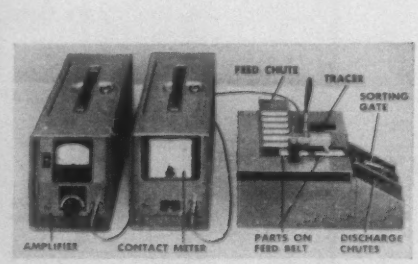


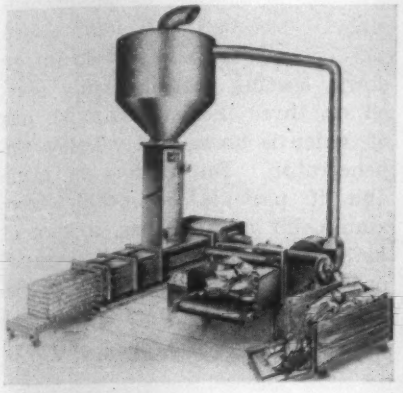
No. 6—

Roughness Sorter

Equipment that permits addition of surface-roughness inspection to automated production setups, sorts parts in accordance with microinch roughness measured along an OD or flat surface, including tapers and parts with grooves or shoulders. Workpieces go from a feed chute onto a conveyor belt which moves them beneath a tracer. As parts leave the tracer, they are automatically directed into an accept or reject discharge chute in accordance with their roughness. Illustrated model has contact meter set to high roughness limit; parts which are that rough or rougher are rejected, while all other parts are accepted. Equipment can be furnished to accept work within a

selected range of roughness, rejecting parts that are either too rough or too smooth. Auxiliary items include equipment for automatic selection of parts to be measured, signal lights and controls to shut down the line after a given number of parts are rejected. **Micrometrical Mfg. Co.**, 345 S. Main St., Ann Arbor, Mich.

Circle No. 6 on Reply Card



No. 7—

Scrap-Paper Baler

As much as 4 tons of scrap paper can be baled per hour, in bales up to 1000 lb each by scrap paper baler called the Cyclomatic. All types of paper can be handled by the unit, including whole or upright corrugated boxes and cartons, box-board, coated stocks, wax and tissue papers and cellophane. Another feature of baler is that it permits complete segregation of various types of papers automatically and without stopping baling operation. Paper is fed onto a feed table and is forced through pinch rolls into a hogger for chopping into small pieces. It then passes under pressure through a pneumatic type conveyor and into a cyclone where air is exhausted and the pieces of paper drop by gravity into the hydraulic baler. Photoelectric switches automatically control ram cycle so that uniform amounts of paper are baled, giving uniformity of size, weight and density of bales. Operator completes cycle by wire-tying bales while other bales are being formed. Cyclone and exhauster can be placed either inside or outside of a building. **East Chicago Machine Tool Corp.**, Balemaster Div., E. Chicago, Ind.

Circle No. 7 on Reply Card

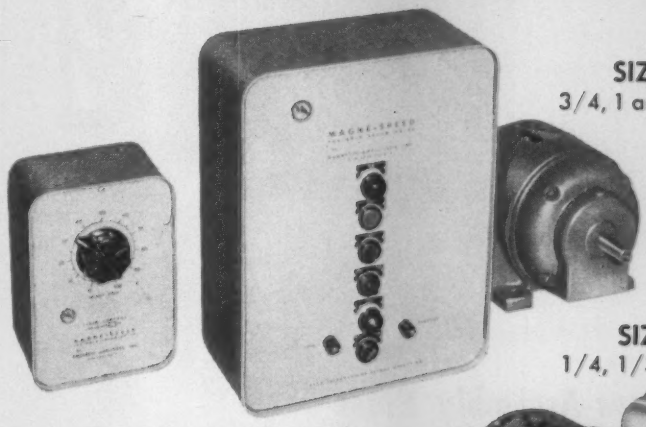
AFFILIATE OF GENERAL CERAMICS CORPORATION

Magnetic Amplifiers · INC

—announces its new

VARIABLE SPEED DRIVE

MAGNE-SPEED*



SIZE II — 3/4, 1 and 1-1/2 HP

SIZE I — 1/4, 1/3 and 1/2 HP

Stepless, instant starting, compact, 50:1 speed range, good regulation without tachometer, long life, virtually maintenance free service, low cost, fast response, reversibility, dynamic brake, local or remote control. Write for Bulletin S580-5-55.

Other MA Products and Services

Magnetic Servo Amplifiers
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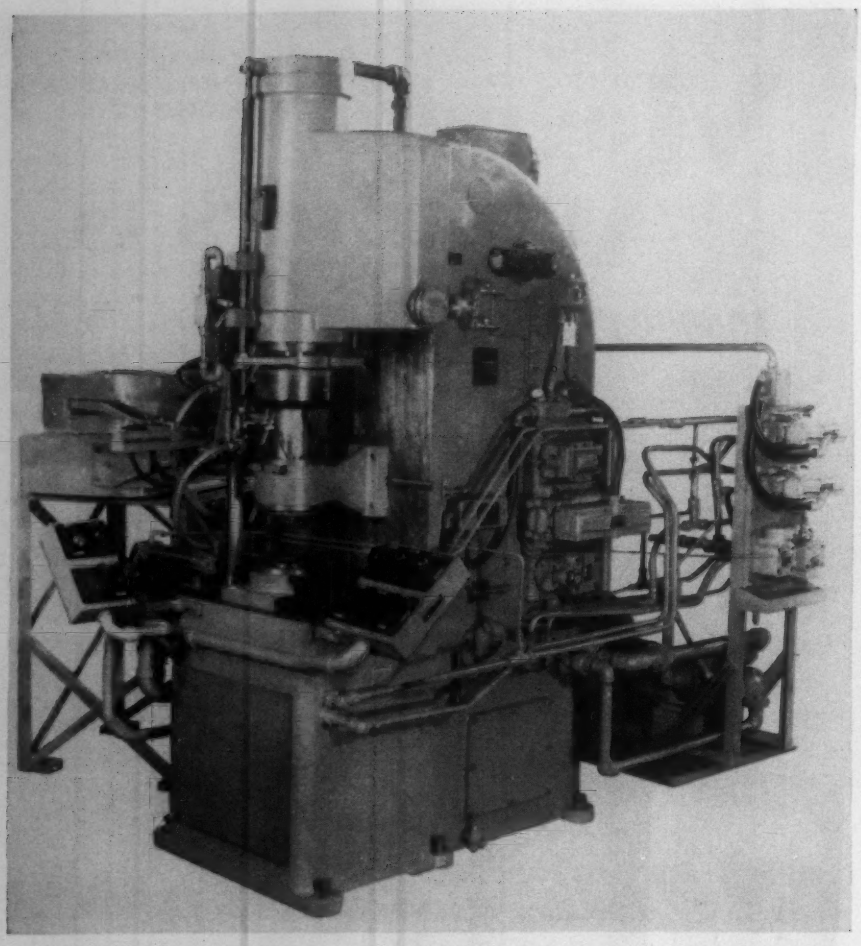
* Trade Name

Application engineering and conversion of tool machines and production processes to automatic control.

Magnetic Amplifiers • Inc

Tel. CYpress 2-6610 • 632 TINTON AVE., NEW YORK 55, N. Y.



No. 8—

Automatic Gear-Assembly Press

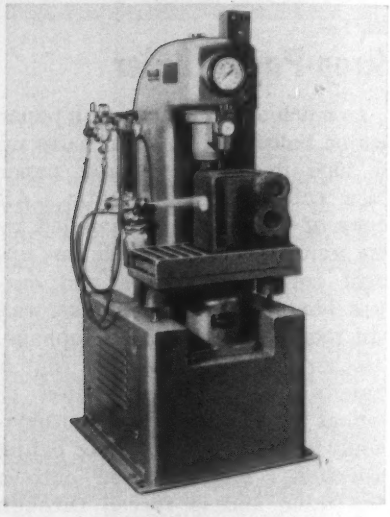
New 25-ton press with electrical controls automatically assembles and stakes the drive flange of an automotive transmission to a pinion gear and then assembles a bushing into the gear. Machine is equipped with special work base, a hydraulic assembly cylinder, hydraulic loader and hopper feed. Spiral bar and nut assembly guides the flange in assembly to helical spline teeth of the gear. Tooling includes helical spline locator and hardened and ground staking tools mounted on ram nose piece. Operator loads a gear in work nest radially locating from one of the gear teeth. He then loads a flange over the splined nose piece of the ram, which locates radially from previously cut internal splines of the flange. Ram descends pressing the flange over the gear and staking the two together. Ram continues to hold the workpiece until a bushing is assembled from under the work nest into the gear. Hydraulic cylinder with cross head and guide bar arrangement interlocked to the machine cycle automatically assembles the bushing into the gear. Bushings are fed continuously by a rotary hopper into a magazine tube feed. Hydraulic loading slide interlocked to the cycle transfers bushings one at a time into assembly position under the work nest. After the bushing has been assembled into the workpiece, ram returns to *Up* position and operator unloads the completed part. Complete cycle for assembly of workpiece is approximately 17 seconds. **American Broach & Machine Co.,** 415 W. Huron St., Ann Arbor, Mich.

Circle No. 8 on Reply Card

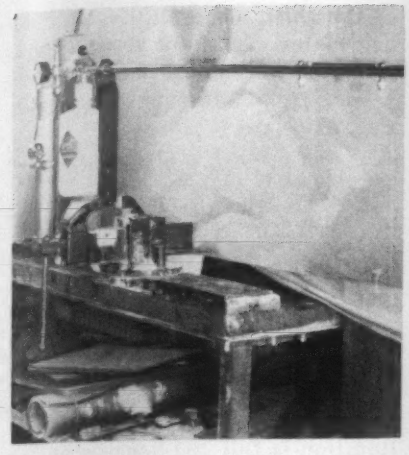
No. 9—

Hardness Tester

Paint spray attachment is feature of new brinell hardness tester. Attachment synchronizes with testing cycle of machine so that relative hardness of parts is automatically indicated by a spot of paint. Tester is designed to fit into a roller conveyor. Castings from foundry are rough ground top and bottom to remove most of scale and then are rolled into place on roller section of tester. Operator locates part by means of a stop located at rear of rollers. He then manually depresses button starting hydraulic cycle of machine. As ball descends toward the casting, roller section drops down, leaving casting firmly seated on three hardened anvils, one of which is immediately below the penetrator. Impression is made and if part is acceptable from standpoint of hardness, a spot of paint is automatically sprayed onto the casting. After a predetermined interval, load is released, ball penetrator retracts and rollers lift up, permitting operator to roll casting down the conveyor to the next operation. At end of conveyor, castings are sorted; those which are not sprayed are sent to heat treating department and accepted castings are sent on for machining. Illustrated model is a single-purpose unit with vertical opening fixed; other models are available with adjustable openings to handle variety of work. Spray units can be cycled with acceptable range or can indicate too hard or too soft specimens. **Steel City Testing Machines Inc.,** 8817 Lyndon Ave., Detroit 38, Mich.



Circle No. 9 on Reply Card



No. 10—

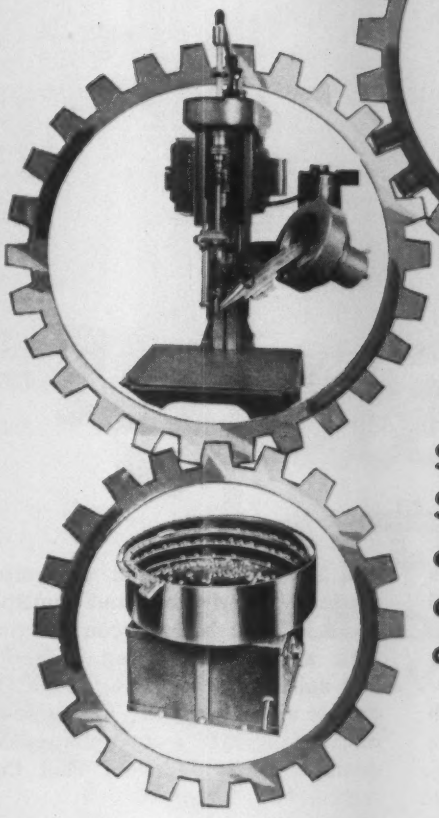
Powder Sprayer

Used for applying powder on polyethylene bags to eliminate stickiness, smear and handling problems, applying talcum powder on extruded rubber products, special granules on moving webs and rubber tubing, atomized asphaltum powder on asphaltum ink before inking on metal plates, powder to prevent stickiness in the food and confectionery field, and as standard production line equipment for television manufacturers, powder sprayer can be readily adapted for production lines to operate automatically in conjunction with other manufacturing processes. Unrestricted adjustability is provided by 360-degree rotation of atomizer heads mounted on swivel arms. Powders, special granules and finely ground materials can be uniformly applied over small or large areas in either continuous or intermittent flows. Mounted on portable stands or stationary assemblies for permanent installation, units are engineered for easy adaptation to any production operation. Illustrated model is equipped with powder applicator assembly with micrometer powder-index dial, quart container, two multiple head telescope arms and five special atomizing caps; solenoid valve with feather contactor switch assembly; air regulator with gage; valves; fittings; airline conditioner to provide clean dry air in the airline, and hose with couplings. **Paasche Airbrush Co.**, 1909 Diversey Parkway, Chicago 14, Ill.

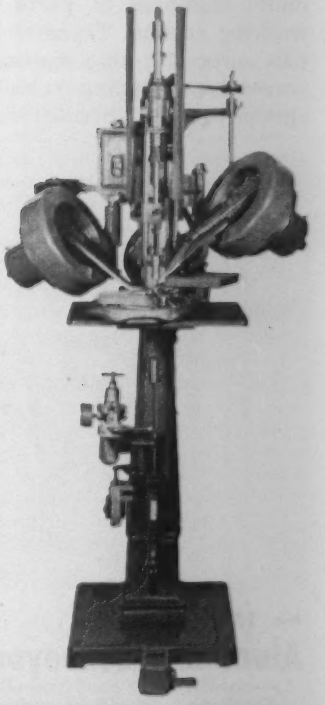
Circle No. **10** *on Reply Card*

Are You Geared to Meet Today's PRODUCTION DEMANDS?

MAXIMUM OUTPUT — MINIMUM COSTS



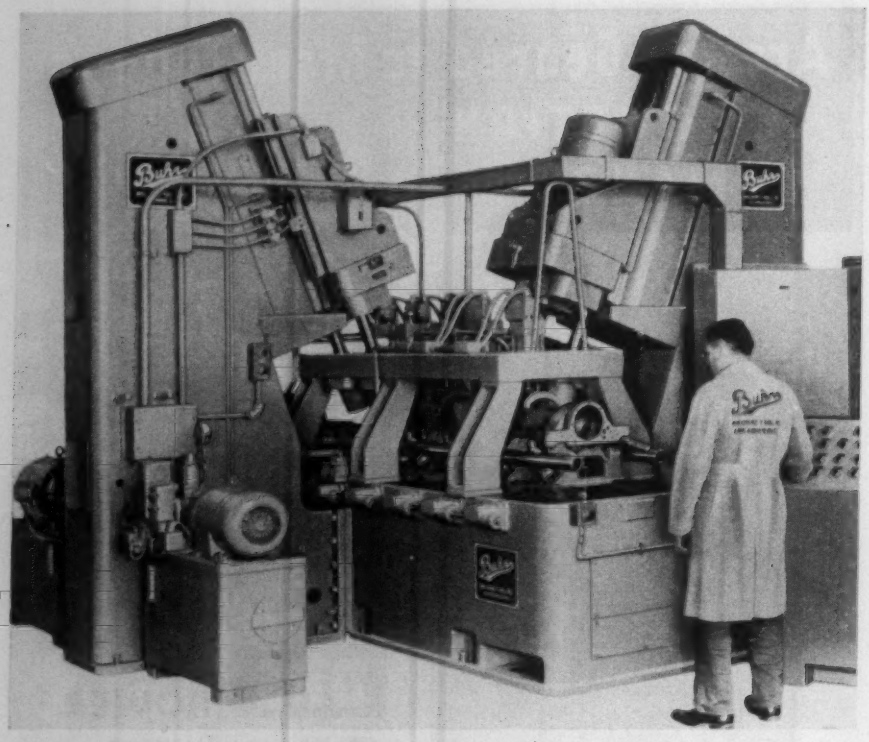
DPS POWER SCREWDRIVERS and SELECTIVE FEEDERS *enable you to meet requirements in today's competitive market.*



● Line up this modern "gear train" for added profits. The DPS Power Equipment line is complete and flexible . . . Adaptable to the majority of production bottlenecks . . . It could be the answer to your problem . . . Tell us your story . . . Send for detailed catalog . . . Write today.

DETROIT POWER SCREWDRIVER CO.

2811 W. FORT ST. DETROIT 16, MICHIGAN

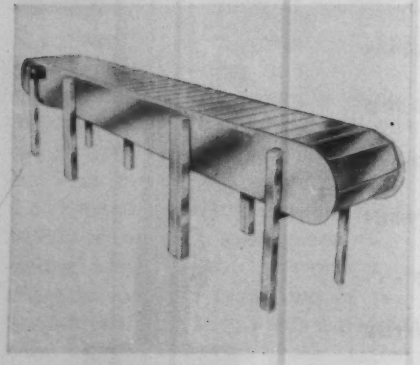


No. 11—

Six-Station Transfer Machine

New machine which chamfers and individual lead-screw taps 105 automatic transmission cases an hour features automatic shuttling of parts between stations and automatic clamping of parts at each working station. Transfer machine has automatic chip disposal, lead-screw type tapping spindles with chrome plated threads, laminated tool steel ways which are automatically lubricated, and multiple heads of ball bearing construction with shaved gears and broached and splined drives. The six-station unit is desiged for use in the automotive, aircraft and appliance industries. **Buhr Machine Tool Co.**, Ann Arbor, Mich.

Circle No. 11 *on Reply Card*



No. 12—

Aluminum Conveyor

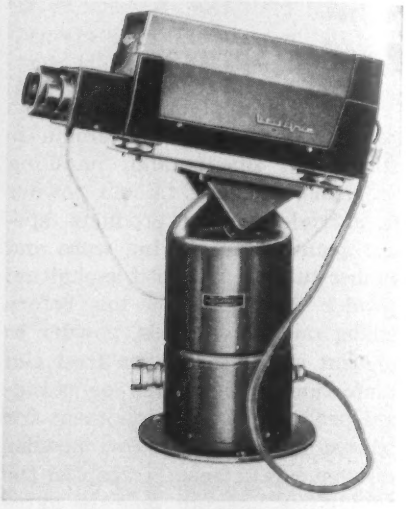
Designed to aid in reducing cost for handling unfinished and finished goods, all aluminum conveyor is well suited for moving parts and assembled goods from assembly lines to shipping points or storage space. Belt plate top will handle and safely convey parts at variable speeds up to 100 fpm in either direction. Belt is fastened to link chain arrangement which is hooked up with drive sprockets which impart smooth and vibrationless drive. Each foot of belt is supported by eight or more rollers; conveyors 18 inches and wider have added center channel support for greater load capacity. Belts are available in widths from 6 to 96 inches and in lengths up to 175 ft or more, depending upon requirements and specifications. Aluminum conveyors are prefabricated in 5-ft sections for quick and easy assembly. Conveyor can be adapted to inclines by addition of cleats which are easily fastened to belt plates. Units are used in food, dairy and chemical fields. **Conveyor Div., Mercury Industries Inc.**, Hillsdale, N. J.

Circle No. 12 *on Reply Card*

No. 13—

Camera Mount

Designed for use with industrial television cameras, remote-control pan and tilt mount features rugged construction. It is used on both outdoor and indoor installations. Rotation is full 360 degrees or can



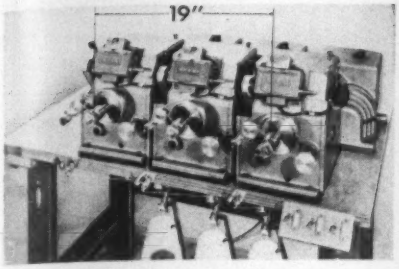
be limited to any arc desired. Tilt is 45 degrees above horizontal and 45 degrees below. Complete 360-degree rotation is accomplished in 36 seconds while 90-degree tilt requires 15 seconds. Pan and tilt motions are driven by separate motors, individually and remotely controlled from a control panel located at any desired point. Mount is especially useful where it is necessary to have one camera cover a very wide area. **Diamond Power Specialty Corp.**, Electronics Dept., Lancaster, O.

Circle No. 13 *on Reply Card*

No. 14—

Bobbin Winder

Front loading multiple header bobbin winder with adjustable length features compact design. Space between winding spindles is 9½-inches. When three spindles are used, two outer spindles are only 19 inches apart. Compactness permits one operator to



handle up to four heads without shifting position. Heads are individually motorized and mounted for easy portability. Each head winds random wound bobbin coils, solenoids, repeater coils or resistors up to 2½-inches long and up to 4-inches OD. Front loading feature speeds production and saves time because spindle faces operator. Infinitely adjustable winding traverse eliminates cam changing, additional cams and cam storage problems. Winding speed is up to 7000 rpm. Other features include instant automatic brake release, automatic lubrication, resetting automatic counter, faster gear changing attained by locating gear box on top of head, positive stopping magnetic brake and one-way clutch which insures positive drive. **Geo. Stevens Mfg. Co. Inc.**, Pulaski Rd. at Peterson, Chicago 30, Ill.

Circle No. **14** *on Reply Card*

No. 15—

Carton Strapper

Fully automatic strapping machine for wrapping, tensioning and sealing steel bands around cartons and boxes is capable of handling a

DELIVERY OFF THE SHELF

IN 64,000 COMBINATIONS

T-J

Spacemaker CYLINDERS

OUTMODE ALL OTHERS . . . SAVE 40% SPACE!

You'll never go back to tie-rod cylinders, once you apply T-J Spacemakers to your push-pull-lift jobs! Advantages in space saved, weight saved, greater strength and off-the-shelf delivery are among the dozens of Extras you get as Standard!

Now—these sensationally popular T-J Spacemaker Cylinders are available off the shelf *in sizes up to 8".* This means as many as 64,000 different combinations of styles, bores, strokes, mountings, etc., *immediately available!* Oil pressure to 750—Air to 200 P.S.I. Super Cushion Flexible Seals for Air . . . New Self-Aligning Master Oil Cushion. Hard chrome plated bodies and piston rods (Standard). Only from T-J can you get these new ingenious cushion designs! Send for bulletin SM-155-2. The Tomkins-Johnson Co., Jackson, Michigan.

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DIVITORS . . . AIR AND HYDRAULIC CYLINDERS . . . CUTTERS . . . CLINCHERS

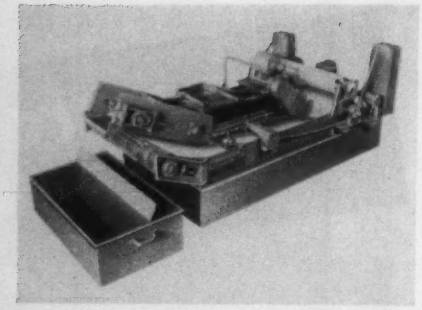
variety of box sizes without adjustment. Machine is adaptable to high production, conveyorized packaging lines. Automatic strapping cycle is initiated by hand lever, pedal or button or, with addition of special equipment, by approach of article to be strapped. Illustrated model will handle all sizes of packages up to 20 by 22-inch girth and will cycle at rate of 18 straps per minute. Other sizes for boxes up to 52-square inches are available. **General Strapping Corp.**, 100 Park Ave., New York 17, N. Y.

Circle No. 15 *on Reply Card*

No. 16—

Coolant Filter

Combined magnetic separator and filter for separation of ferrous sludge and abrasives from coolants has high magnetic attraction. Unit uses new method of gravity flow and magnetic attraction. Through efficiency of magnets in handling swarf load, filter size has been reduced while flow capacity has been increased. Combined magnetic separating and filter units are continuous, full flow ca-



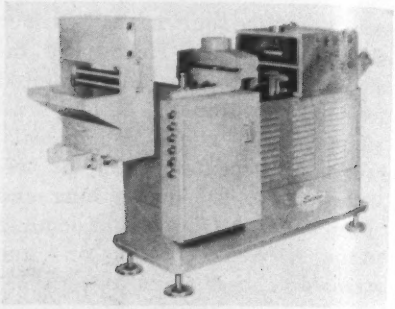
pacity, self-cleaning and fully automatic. Tote box with dividing plate separates swarf from the used paper. Disposal is quick and convenient. **Industrial Filtration Co.**, Dept. CM-471, Lebanon, Ind.

Circle No. 16 *on Reply Card*

No. 17—

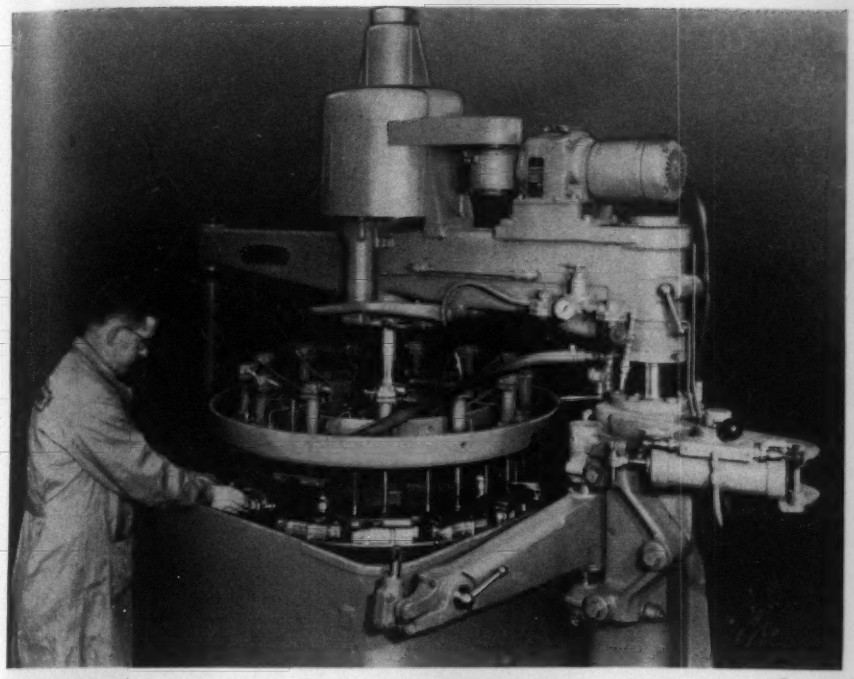
Gripper Feed Unit

Hydraulically operated gripper feed unit can feed into press from right, left, front or back. It will feed stock of any width up to 20 inches or can be so designed to take up to 48 inches. Unit feeds within 0.003-inch or less of the selected setting. Cycle of unit is timed by stroke of press ram. Hydraulic tank assembly serves as base of press feed unit and is a reservoir on which other subassemblies are mounted. It has a front stock guide and rear stock guide assembly, gripper assembly, stock retainer assembly, motor and pump assembly, four adjustable floor legs and conveniently positioned control panel. Rear stock guide assembly is adjustable to handle



stock from maximum width of 48 inches down to minimum of ½-inch wide. Gripping mechanism consists of double-action hydraulic cylinder, sequenced with feed stroke, to permit accurate feeding. Unit provides pinch grip pressure of up to 6000 lb. **Sesco Inc.**, 8881 Central Ave., Detroit 4, Mich.

Circle No. 17 *on Reply Card*

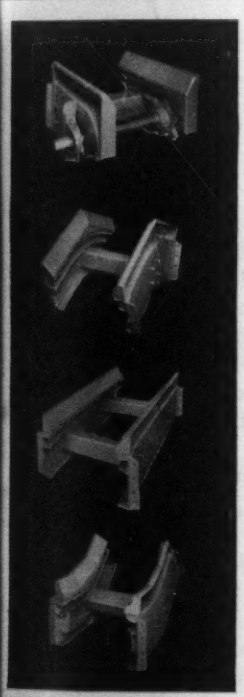


No. 18—

High Production Lapping Machine

Designed for either single or parallel face flat lapping, high production lapping machine can be arranged for timed cycle, automatic continuous feed or semiautomatic continuous feed. For single face lapping, machine mounts a single 48-inch diameter bonded abrasive wheel-lap on a rigidly supported, heavy duty, vertical spindle. Workpieces are retained in adapters and lapping pressure is secured through weights or pressure devices as required. Opposed parallel flat faces can be lapped in the machine simultaneously. Plain, timed cycle arrangement uses an electric timer to control the machine cycle. Operator removes finished parts, inserts rough parts and then presses a pushbutton to start the cycle which is terminated automatically by the timer. With the semiautomatic continuous feed arrangement, operator removes finished work and replaces it with new parts as lapping is done continuously in a single pass through the laps. Automatic continuous feed arrangement eliminates loading and unloading functions of operator and places work in automatic handling equipment. Machine has bonded abrasive wheel laps in conjunction with filtered coolant. Individual adjustable speed drives for laps and workholder give flexibility. **Norton Co.**, Worcester 6, Mass.

Circle No. **18** *on Reply Card*



Now you can buy CUSTOMIZED conveyors in pre-fabricated STANDARD sections

In a **single glance,** you can see all of the advantages of MAY-FRAN STANDARDIZED components.

The five standard sections shown can be assembled to form virtually any type of *"customized"* conveyor for the handling of stampings, formed metal parts, forgings, automotive scrap, chips and turnings.

Straight sections . . . concave or convex sections . . . take-up charge and discharge-end sections can be furnished to meet specific requirements of belt width as well as load bearing and volume capacities.

A single glance at the MAY-FRAN conveyor standardization program, and you will see savings never before possible. In addition you will see unsurpassed conveyor flexibility.

MAY-FRAN . . . a name long recognized in the materials handling field . . . is **FIRST** again with *standardized* components for your *customized* installation.

Write today for complete information.

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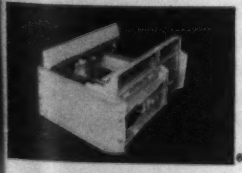

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1761 Clarkstone Road • Cleveland 12, Ohio

NOW... Noise Free A.C. Power!

NEW CURTISS-WRIGHT DISTORTION ELIMINATING VOLTAGE REGULATOR

- Reduces typical power line distortion to less than 0.3%
- Furnishes 1.4 KVA of distortion-free power
- Electronically regulates 115 V output to ±1%
- Recovery time less than 1/50 cycle
- Provides additional 4 KVA of ±1% electromechanically regulated power
- Electromechanical time constant only 0.6 seconds
- Electromechanical regulator, unlike usual magnetic voltage stabilizer, introduces no distortion or phase shift

Here at last is the ideal solution to the disturbing problem of harmonics and low frequency noise appearing in 115 V., 60 cps power sources. In one compact package, every laboratory can now obtain *both*

1) distortion-free, regulated power when needed, and simultaneously

2) a large supply of electromechanically regulated power for applications where normal line distortion is tolerable.

In addition to its general laboratory utility, this instrument is ideally suited for preventing instability and inaccuracy in a.c. computer system nulling operations. Many other applications. 230 V. model also available. Immediate delivery. $1,689 f.o.b. Carlstadt, N. J. Write for details.

Component & Instrument Department

ELECTRONICS DIVISION
CURTISS-WRIGHT
CORPORATION • CARLSTADT, N. J.

No. 19—

Stacker For Inverting Paperloads

Called the JackStacker, new unit features a rotating clamp for inverting skid loads of paper for rerun through press in printing process. JackStacker has two clamping arms independently operated by hydraulic cylinders, one above the load and the other beneath the load. Load rests on a skid and another skid is placed in inverted position on top of the load. When the load and two skids are clamped, they are raised approximately 1 ft and rotated 180 degrees. Paper is then ready for its rerun through the press. Truck has a capacity of 3000 lb at load length of 56 inches, and clamping arms 26 inches wide by 42 inches long. Lifting height is 84 inches, enabling JackStacker to double deck skid loads of paper in storage area when it is not being used for rotating. Clamping arms can handle loads from 32 to 60 inches high, including underneath skid. JackStacker has four-point suspension with load carrying frame supported on its four corners by stabilizing casters and rear load wheels. Weight of truck and load is distributed over five wheels for floor protection. **Lewis-Shepard Products Inc.,** Dept. R-24, Watertown, Mass.

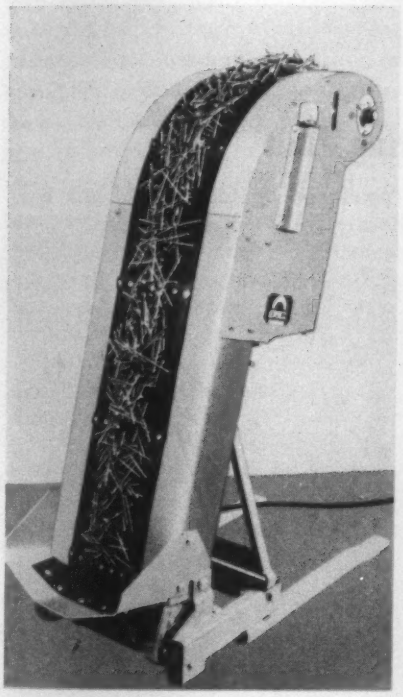
Circle No. **19** *on Reply Card*

No. 20—

Magnetic Conveyor

Permanent magnetic elevator conveyor is designed for automated handling of items such as bottle caps, cans, nails, bolts, blanks, finished parts, scrap, etc. Extended transition section which permits easy discharge into carts, pallets, bins or into other machinery in a

line has a bed which is curved on a radius of 15 inches to allow handling of relatively large objects with high centers of gravity. Fork-like legs of base, only 1½-inches high at highest point, will fit under low pallets, skids, machines, etc., conserving floor space and providing for close operation wherever desired. Inclined magnetic bed of the unit is readily adjustable to any pitch from 60 to 90 degrees relative to floor line. Features include lower production costs by reduction of manual handling; increased production by cutting down loading, unloading and handling delays; increased quality because parts are not damaged by piling



up and hitting each other; shorter lengths of conveyor lines; safer operation by eliminating hazardous handling of sharp or jagged objects and reduced manpower fatigue. Unit is equipped with two 4-inch diameter wheels placed to facilitate easy maneuvering down aisles, around corners and between machines. Supplied in stock bed lengths of 4, 5 and 6 ft, with other lengths available on request, conveyor has a three-ply, 8-inch wide B. F. Goodrich automation belt, furnished either with or without cleats. **Eriez Mfg. Co.**, Erie 6, Pa.

Circle No. **20** *on Reply Card*

The most advanced developments in electronics are being made in the sphere of airborne radar and related ground control systems because of military emphasis.

Further applications of electromechanical techniques in these fields are creating new openings in the Systems Division of Hughes Research and Development Laboratories.

Engineers who have demonstrated ingenuity and inventive ability will find interest in areas of work that call for devising reliable, maintainable, manufacturable designs for precision equipment developed at Hughes Research and Development Laboratories.

The design of this equipment, manufactured at Hughes, involves mechanical, electromechanical, electronic, microwave and computing problems. Design also requires the use of such advanced techniques as subminiaturization, unitized "plug-in" construction, with emphasis on design for volume production. Knowledge of electronic components, materials, finishes and military specifications is useful.

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Culver City, Los Angeles County, California

assembly line bottlenecks with special machines

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Traffic jams on your assembly line may be cancelling out all your production savings with automation.

Special assembly machines may speed operations to keep pace with production. Why not find out? You may get additional dividends, too, because rejects and spoilage are cut far below minimum human error by the accuracy of machines.

Let us tell you about some of the assembly machines we've engineered. No obligation, of course. *Write or call.*

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New PRESET COUNTER *by* **FREED**

MODEL 2020

The Freed Model 2020 Preset Counter is designed for low cost reliable counting applications, where accuracy and maintenance-free operation is required.

Cold cathode counting and trigger tubes, with simplified circuits, are used throughout which assure years of trouble-free counting service and low-power consumption.

Model 2020 is a 4-digit single preset counter capable of controlling any operation that is repeated up to 9,999 times. Any number from 1 to 9,999 may be preset on the 4-digit selector switches. When the preset total has been reached, the counter will provide an output pulse and close contacts on a relay. These outputs may be used simultaneously or separately to stop machines, actuate control signals, or trigger additional equipment.

SPECIFICATIONS

Maximum Count: Four digits — 9,999	**Pulse output** 50 volts
Maximum counting rate: 300,000 counts per minute	**Size:** 8 x 6 x 12 inches
Input Sensitivity and Waveform: Not critical	**Weight:** 11 pounds
Outputs: Relay contact 10 Amperes	**Power:** 25 watts 105-125 volts, 50-60 cycles
	Price: $425.00

Freed also manufactures Totalizing, Preset, and Batching Counters

SEND FOR COMPLETE INFORMATION

Engineering assistance available for adapting these counters to your specific applications.

FREED TRANSFORMER CO., INC.

1705 Weirfield Street
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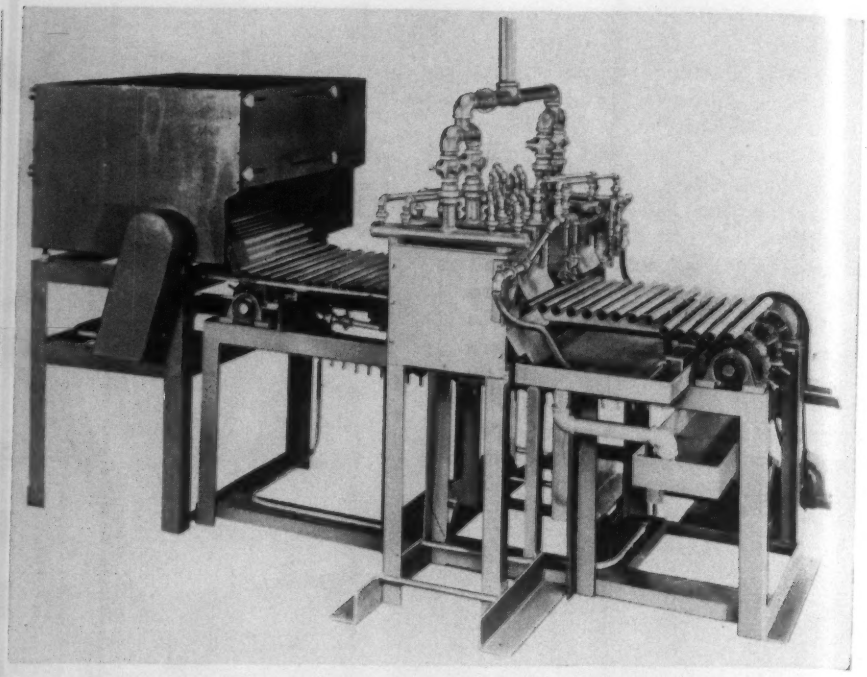
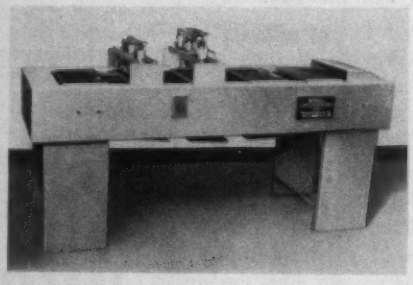


No. 21—

High Speed Automatic Heating Unit

Designed to increase end-annealing production of brass tubes for manufacture of sink traps, high-speed gas-fired heating unit is completely automatic in operation. Tubes are fed by an automatic hopper to an endless conveyor which carries them through a heat zone, heating both ends of the tubes simultaneously to a specified length, prior to bending or flaring. Heat zone consists of two high speed end heating furnaces, mounted on wheels, to permit adjustment for various tube lengths and to control length of tube section to be heated. Rapid heating in reducing furnace atmosphere (produced by high speed gas burners), followed by a water spray quench prevents oxidation, and produces a sharp line between annealed and unannealed portions of tube. Tubes discharged from end of conveyor are ready for forming operation. Unit is adjustable to heat from ½ to 7 inches of each end of tubes, and will handle 1 to 2-inch diameters, with overall lengths ranging from 12 to 36 inches. Production of illustrated unit is 750 pieces of the 1½-inch size per hour. **Gas Appliance Service Inc.,** 1211 Webster Ave., Chicago 14, Ill.

Circle No. **21** *on Reply Card*



No. 22—

Glass Cutter

Automatic glass cutting machine cuts and cracks off glass, replacing hand operations in glass production. Machine is available in series of sizes capable of automatically cutting and cracking off glass circles and other patterns from 2 to 6 inches in diameter. Machine can be furnished with automatic loading and unloading equipment to make the entire operation automatic. Capacity of new machine is approximately 1200 pieces per hour. Equipment will also be available for cutting and cracking off larger designs. **Biddle Enginering Co.,** Box 48, Warrendale, Pa.

Circle No. **22** *on Reply Card*

Louden Selectomatic-Automatic Dispatch

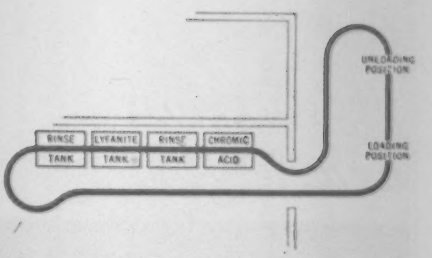
Louden's contribution to* AUTOMATION *here saves $25,000 a year

Louden Selectomatic-Automatic Dispatch is an application of automatic, unattended operation to materials handling and as such is serving many large industrials the country over. It is further indication of Louden's ability to turn the fundamental advantages of overhead handling to greatest account. The typical installation shown here is in the Johnson Motors, Waukegan, Ill., outboard manufacturer plant. Its function is to carry aluminum parts through a Lyfaniting (anti-corrosion) process. The moment its basket is loaded by one man and the button pushed, it carries on by itself, dipping basket contents into a series of tanks for stipulated periods of time, and then running its load to a second man who unloads it. The Selectomatic-Automatic Dispatch System replaces a hand-operated monorail system and accomplishes in *one* shift what it used to take 3 shifts to do. On an initial investment of only $16,000, this user is saving in excess of $25,000 a year!

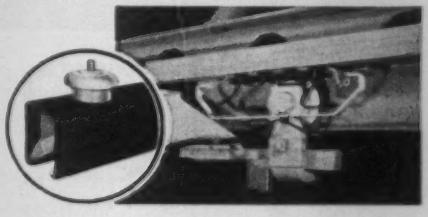
The availability of such equipment is a reciprocating testimonial to the breadth and penetration of Louden engineering. Truly Louden turns to greatest account the advantages of overhead handling—providing the finishing touch that makes the difference between "pretty good" and outstanding. Call in a Louden man for help on *your* handling problems.

THE LOUDEN MACHINERY COMPANY
6802 Broadway, Fairfield, Iowa

A Subsidiary of Mechanical Handling Systems, Inc.



Louden Selectomatic-Automatic Dispatch embodies the principle of automatic control as applied to materials handling operations. In some installations, it even exemplifies true AUTOMATION. By combining monorail track, the appropriate current-carrying and current-controlling devices, motorized conveyors, and the appropriate type of carriers, the completely automatic and unattended handling, carriage and processing of many materials and parts are achieved. Impressive economies, production increases and quality improvement are the result.



New! Louden Shokpruf Electrification . . . for all monorail and crane installations. Hazards of open conductor bars now completely overcome by this exclusive Louden engineering development. Write for full details of this safe conductor system.

Louden

MONORAIL & CRANES

SINCE 1867...THE FIRST NAME IN MATERIALS HANDLING

for production brazing...

LUCAS MILHAUPT
SILVER BRAZING
PREFORMS

RINGS
Round Wire, Machine Wound, Mandrel Wound.

RINGS
Flat Wire, Machine Wound, Mandrel Wound.

ODD SHAPES
Any size or form.

WASHERS
Edgewound and Blanked.

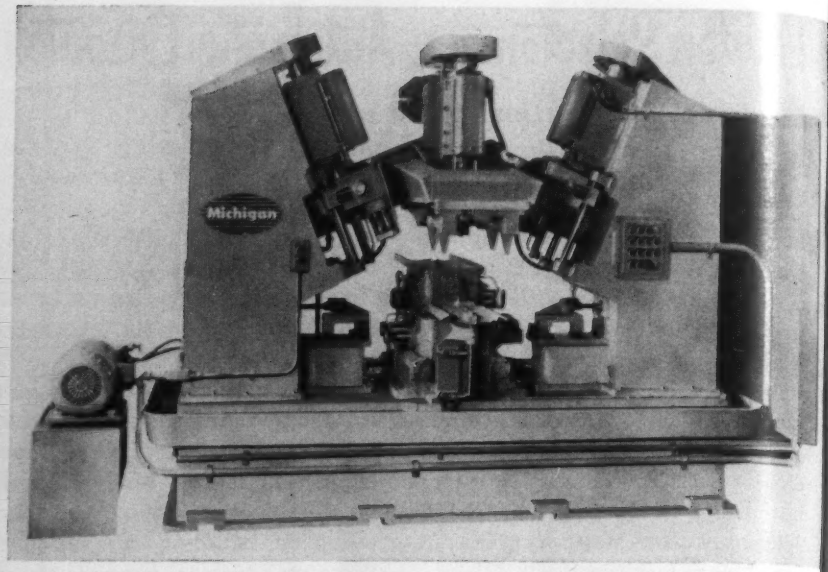
Preforms in any size or shape that...

1. End Wasted Time In Placing Silver Solder in position for brazing.
2. Speed Assembly Work.
3. Eliminate Rejects.
4. Meter Silver Solder to Flow In and Around Joints.

To do your silver brazing job better, Lucas-Milhaupt offers a wide range of silver brazing preform sizes and shapes. In addition to round and flat wire rings, blanked and edgewound washers, Lucas-Milhaupt provides a complete line of preforms which include such shapes as elliptical, rings, hinged rings, segments, slugs, U clips, hairpins, etc. Send your drawings or sample part and the proper preform will be designed to do your brazing job faster at less cost.

FREE... 16 page booklet gives you all the facts on better brazing with preforms. Write Today!

5056 SOUTH LAKE DRIVE • CUDAHY, WISCONSIN



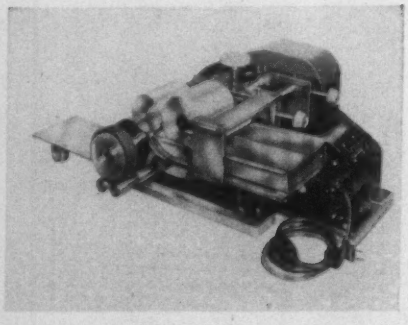
No. 23—

Automobile Frame Drilling Machine

New machine which features an eight-spindle Angle-Matic head is designed for drilling automobile frames. It drills 19 holes at various angles in each frame at rate of 160 frames per hour. In operation, machine automatically positions frame over locating pins; automatic elevators lower frame and clamps automatically secure frame in place preparatory to drilling; when completely secured, all tools advance.

The coolant is supplied to tools automatically. Components consist of two five-spindle drill heads and one single-hole driller, mounted on self-contained power units, and one eight-spindle Angle-Matic head. Spindles in Angle-Matic head operate as follows: two are fed horizontally to the left, parallel with front of machine and two are fed horizontally to the right; two are fed horizontally to the left, at 60 degrees to the front of machine; and two spindles are fed to the right at 60 degrees, using only one feed mechanism. After all 19 holes have been drilled, frame is unclamped, raised to conveyor height and ejected from machine automatically. **Michigan Drill Head Co.**, P. O. Box 4643, Detroit 34, Mich.

Circle No. **23** *on Reply Card*



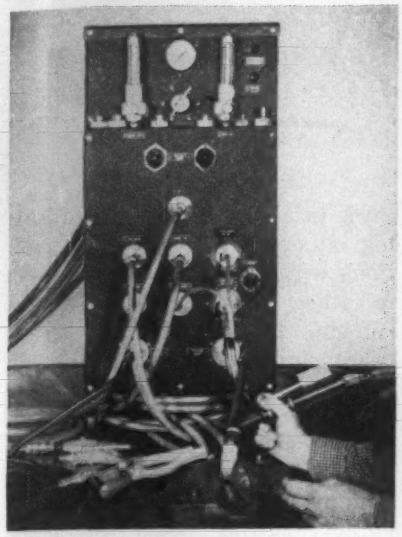
No. 24—

Margin Gluer

Topside margin gluing machine is well suited for mass production setups because it delivers work coated-side up. Gluer can be mounted over a conveyor so that the coated material is carried along for further processing or for drying. Because it is applied to the topside of material, operators can readily inspect the coating. Glue or other coating material can be applied in one or more strips, edges only or complete overall coating. Machine handles all types of liquid glue including latex. Simple adjustment allows coating with materials of varying thickness, flexible or rigid. Roller arrangements are available to suit specific needs in brass or stainless steel, depending upon the nature of the adhesive. Margin gluer can be equipped with a thermostatically controlled heated tank. Reservoir is easily removable for quick cleaning. Str

gluing rollers are also available in various widths. **Potdevin Machine Co.**, 285 North St., Teterboro, N. J.

Circle No. 24 on Reply Card



No. 25—

Welding Controller

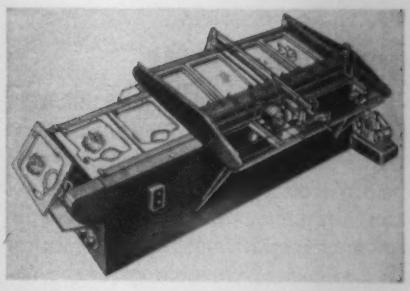
Portable, high-frequency welding control unit is designed for inert gas shielded arc welds using conventional welding machines. Unit provides automatic control of torch and back-up gas, torch and fixture cooling water, high-frequency starting spark and welding current. Welding current input may be from motor-generator, rectifier, transformer, or gas engine driven generators. Controller also features welding current polarity indicator, back-up and torch-gas flowmeter receptacles for conventional arc welding, air pressure regulator with air supply fittings, and 110v auxiliary power receptacles. **Flexweld Mfg. Co.**, Depot St., Buckland, Conn.

Circle No. 25 on Reply Card

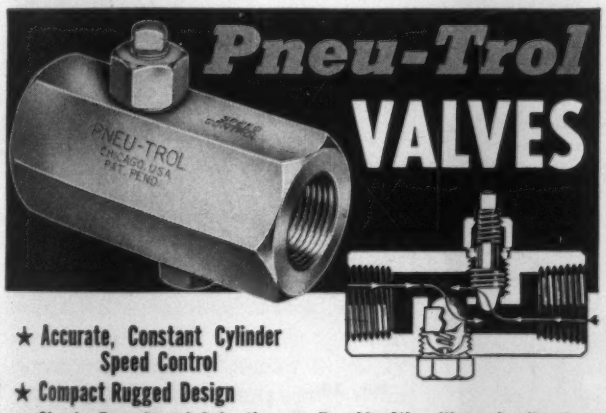
No. 26—

Silk Screen Press

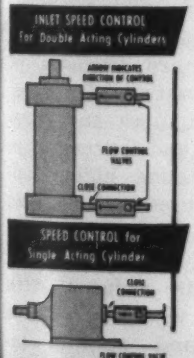
Designed to automatically screen textile and paper products in two or more colors in a single operation, silk screen press was originally developed for use in the textile field. Addition of built-in, infrared drying oven for paper products that presently need racking, allows same paper materials to be dried in the oven before receiving a second screening. Unit is therefore adaptable for use in screening both textile and paper. Entire operation, multiscreening and drying, is completed in approximately same span of time it takes to monoscreen an item. Press operates on a conveyor principle. Automatic timing device moves the platforms from one color to another in a mechanical sequence which insures accurate registration. Automatic two-way squeegees are adjustable for light or heavy pressure. After each coloring, material is conveyed through infrared drying oven and within a matter of seconds, is in position for the next color. **American Automation Inc.**, 175 W. Jackson Blvd., Chicago 4, Ill.



Circle No. 26 on Reply Card



★ Accurate, Constant Cylinder Speed Control
★ Compact Rugged Design
★ Simple, Easy Speed Selection ★ For Air, Oil or Water Applications



Pneu-Trol Speed Control Valves, are widely used in hundreds of control applications because they combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to its seat, requiring only a slight differential pressure to fully open or close it.

Needle design permits maximum flow capacity in the controlled direction. Metal to metal needle and ball seats insure long trouble-free service. Simple, practical "O" gland structure eliminates troublesome leaking. Valve bodies machined from hex brass or aluminum for 2000 psi working pressures; steel and stainless steel for 5000 psi. Made in 5 female pipe sizes—⅛" to ¾". ATTRACTIVE PRICES . . . IMMEDIATE DELIVERY.

Write for illustrated circular and prices.

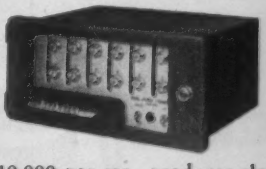
Pneu-Trol DEVICES, INC.
1420 N. KEATING AVENUE • CHICAGO 51, ILL.

Berkeley news notes

NEW model 5846 MAGNETIC DUAL PRESET COUNTER

- *continuous-duty reliability!*
- *simplified installation, operation, maintenance!*

BRIEF SPECIFICATIONS
INPUT SENSITIVITY:
0.1 ma p-p into 10k load
OUTPUT SIGNAL:
5 amps (non-ind.)
ACCURACY: ABSOLUTE
PRICE (F.O.B. FACTORY):
model 5846 (6 digit)
$1,295.00.



Counts at rates to 10,000 per sec., produces electrical output signals at any two preset totals. Absolute accuracy. Operates from photocells, magnetic pickups, electrical contacts. Built-in DPDT output signal relay operates solenoids, solenoid valves, power relays, other control devices. First signal may be used to slow down operation preparatory to stop at final (second) count, etc. Has only two vacuum tubes (vs. 54 in electronic model), both used in low-level rf oscillator-power supply. Tamper-proof transparent cover, swing-out chassis construction.

Write today for Technical Bulletin; please address Dept. V2.

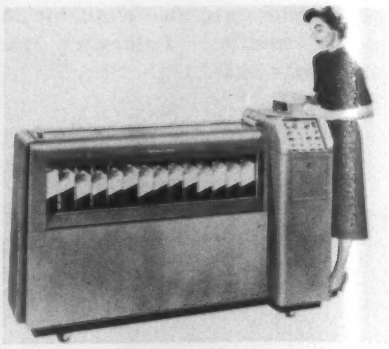
Berkeley
division of Beckman Instruments Inc.
2200 Wright Ave., Richmond 3, Calif.

80

No. 27—

Electronic Sorter

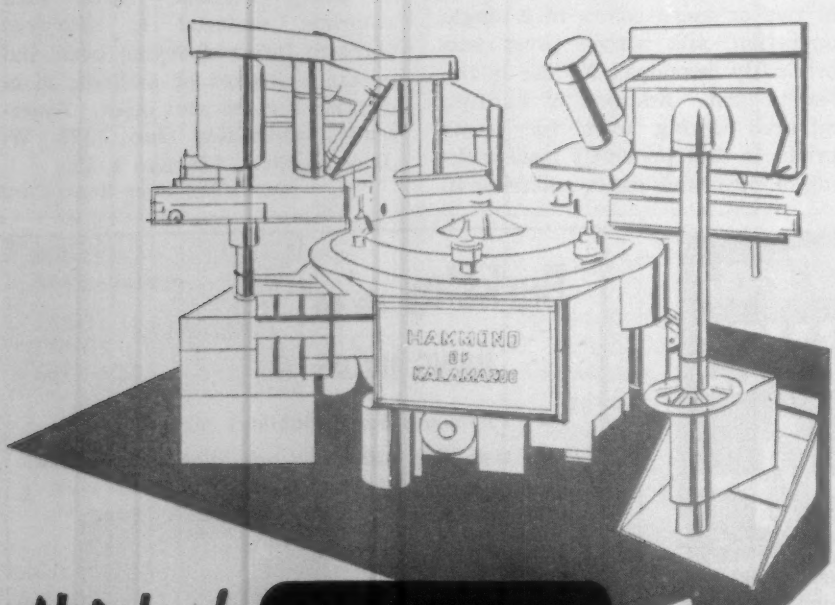
Up to 48,000 alphabetic, numeric, blank and special code punched cards are sorted per hour by new photoelectric machine. Pushbutton simplicity of electronic sorter assures instant selection of column to be sensed; variable sequence affords sorting 0 to 9, A to M, and N to Z cards in any order. Complete alphabetic sort or a complete alphanumeric sort is provided through 13 receivers for cards selected automatically, plus a 14th receiver for nonselected cards. Double capacity feeding magazines and card receivers permit efficient extra output for the unit. Procedure flexibility provides unlimited freedom in segregating and merging up to 13 groups of alphabetic and/or numeric characters selected in a single pass of cards, and in blank selection for merging unpunched cards with zero punched cards, segregating unpunched



cards in a separate receiver. Sorting on one or more control positions without regard for punching in other positions of the same column, for sorting by special codes, and for sorting cards with bottom edge leading, are handled by individual or transposed position sensing. Photoelectric sensing permits sorting of 800 cards per minute with dependable accuracy, cutting down the actual speed of card travel through the sorter and reducing card wear to a minimum. **Remington Rand Div., Sperry Rand Corp.,** 315 Fourth Ave., New York 10, N. Y.

Circle No. 27 on Reply Card

When you think of finishing & deburring

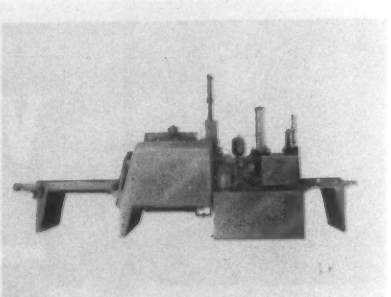


think of Hammond

70 years building machinery has provided us with a bank of "Know-How." Our business is to share this with you, as we have with hundreds of America's leading manufacturers.

Your finishing problem is one our engineers will study to determine what savings are possible when employing modern Semi-Automatics, Automatics or Automation methods.

Hammond Machinery Builders
1650 DOUGLAS AVENUE • KALAMAZOO, MICHIGAN



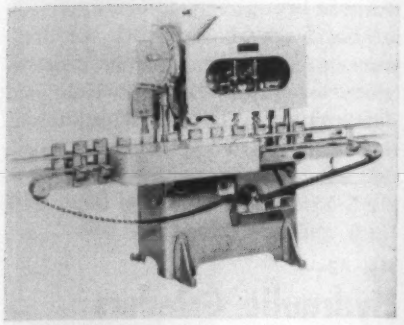
No. 28—

Heat Treating Furnace

Greater loading, heating and quench capacity are features of line of heat treating furnaces. Long-life ceramic tubes and redesigned elements and burners are capable of generating higher operating temperatures quickly and economically. Atmosphere circulation has been stepped up and maintenance costs reduced with new fan design which eliminates welded blades and permits increased life at higher temperatures. Heavier transfer chains are capable of handling much greater loads.

Furnaces include completely redesigned quench tank arrangement which has increased circulation of oil as much as 300 per cent. Quench tank itself is 50 per cent larger in capacity and located as far from heat zone as possible for greatest safety. Tank is completely insulated, and quench rack elevator speed has been stepped up for greater process control. **Ipsen Industries Inc.,** Rockford, Ill.

Circle No. **28** *on Reply Card*



No. 29—

Automatic Can Sealer

Designed for use in the edible oil industries, can sealer operates at a speed of 60 cans per minute, up to quart size. No time is lost in handling containers because they enter the automatic sealer directly from the filling machine. Can sealer is used for both large and small plants, for continuous or short runs. It seals cans using the standard 1-inch seals. Larger seal models are also available.

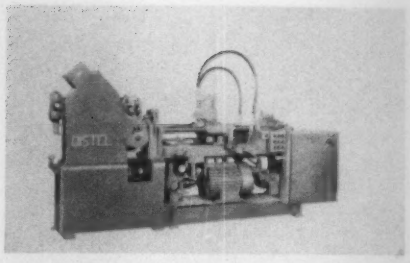
Prior to operation, the hopper is loaded with lids, a few adjustments are made to suit the can being run, and the sealer is ready for production. Changeover from one size container to another can be made in a matter of minutes. Center-hole cans from pint to gallon sizes and off-center cans up to quart size can be handled by the machine. **Resina Automatic Machinery Co. Inc.,** 572 Smith St., Brooklyn 31, N. Y.

Circle No. **29** *on Reply Card*

No. 30—

Cutter and Former

Improved roll form and cutoff machine provides constant roll forming and cutoff from coil stock.

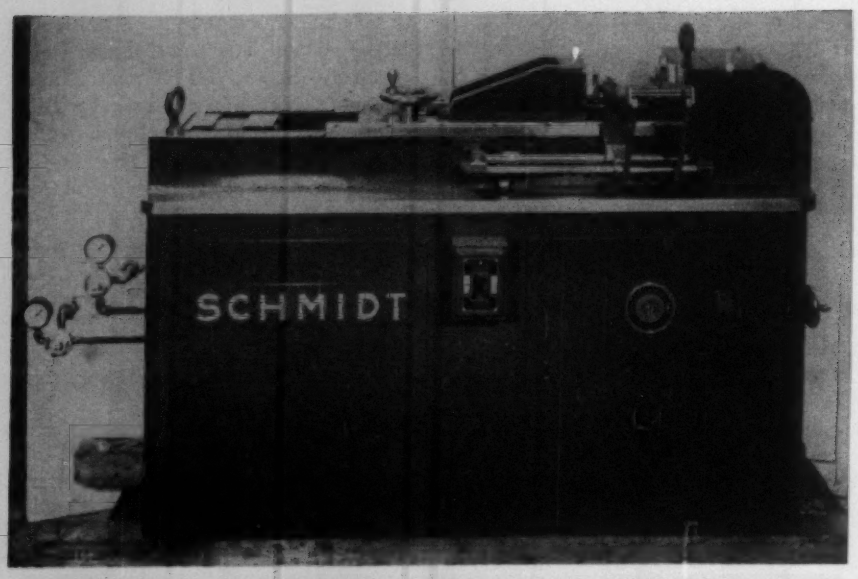


Machine feeds to roll form and cuts off after forming. It features positive locking, both vertically and horizontally. Stock feed guide bars are hardened and ground. Stock feed runs on ball bearings, and double-action cylinders assure rigid control of lengths. Unit produces circular bands because radius is held constant at both ends.

Improved machine is designed to produce bands with diameters ranging from 6 to 10 inches. **Distel Tool & Machine Co.,** 2585 Beaufait, Detroit 7, Mich.

Circle No. **30** *on Reply Card*

March 19-23
See the
Blue Ribbon Winners of 1956
The 453 selected
TOOLING CHAMPIONS
plus 27,898 runners-up
The best and latest in *tools, machines, inspection equipment, automation devices, controls and accessories to cut costs and boost profits—many never before shown anywhere.
For the small plant
For the intermediate plant
For the big plant
See them at ASTE's Greatest Show
1956 ASTE INDUSTRIAL EXPOSITION
International Amphitheatre
CHICAGO, ILLINOIS
MARCH 19-23, 1956
Sponsored by the 32,000 men responsible for designing and selecting the best in production equipment. Write for advance registration blank today.
Equally important, plan to attend the 5-day, all-industry conference covering the latest developments in manufacturing techniques and equipment.
AMERICAN SOCIETY OF TOOL ENGINEERS
10700 Puritan
Detroit 38, Michigan



Power for impression is obtained through a pneumatic cylinder operating at from 60 to 100 psi pressure, depending on marking requirements. Production speed is adjustable by means of a hand wheel. Ram speed is electrically timed to spider speed, and is thus automatically synchronized. In operation, adjustable feeder and discharge chute are set for length of part. Die holders are positioned vertically in angular gibs which automatically center the marking. Ram is brought in or out by means of hand wheel, and with air pressure set to give proper impression, operator trips switch and feeds parts. **Geo. T. Schmidt Inc.**, 4108 Ravenswood Ave., Chicago 13, Ill.

Circle No. **31** *on Reply Card*

No. 31—

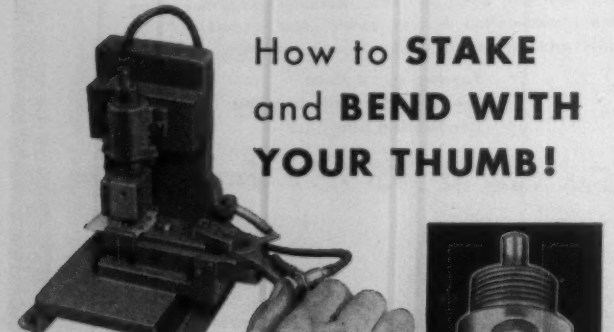
Pneumatic Stud-Stamping Machine

Designed to imprint ends of studs or solid cylindrical parts automatically, pneumatic stud stamper operates at rates from 1000 to 2000 per hour. Studs may be marked on one end or on both simultaneously. Adjustable chute to which they are fed will accommodate sizes from ½ to 1½-inch diameters, by 3 to 12 inches long. Parts are positioned by means of a spider, which locates and holds them, while ram in tail stock makes identification. After marking, spider resumes rotation, ejecting parts into discharge chute.

No. 32—

Hydraulic Grinders

Unique design features for traverse and infeed grinding of medium size parts are incorporated in new hydraulic grinding machines. Bearings consist of multiple segments, fixed axially but free to



How to **STAKE** and **BEND WITH YOUR THUMB!**

NEW! Clippard 3-Way Miniature Air Valve MAV-3

One of the hundreds of time and work saving uses for the *new* CLIPPARD Miniature 3-Way Normally Closed Air Valve is shown above. Jig is constructed so that a force of 75 lbs. is exerted on work by a 1" air cylinder (operating at 100 psi) when manual push-button is pressed. Stem travel of new MAV-3 Valve is 1/16" with overtravel of 1/32". Valve will handle up to 150 psi. Roller Cam-follower Head and a complete line of miniature Air Cylinders, Manifolds, Fittings and Accessories also available for that new automatic, or semi-automatic project you are now developing. Write, today, for details, catalogue sheet and prices.

Clippard INSTRUMENT LABORATORY, INC.
7350 Colerain Road, Cincinnati 24, Ohio

Manufacturers of R. F. Coils, Electronic Equipment, Miniature Pneumatic Devices

Electronic Engineers

Opportunities Unlimited...
with the manufacturers of DATATRON Electronic Data Processing Machines

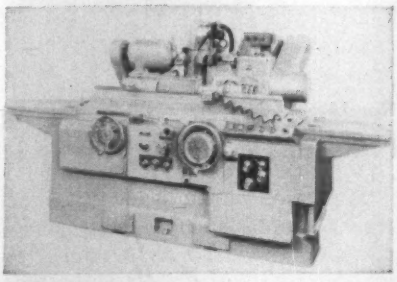
ElectroData Corporation has become in little more than a year the third ranking company in the digital computer field. The company recently moved into its new, ultra-modern, 40,000 square foot plant—completely air and sound-conditioned—in Pasadena's scenic Hastings Ranch area. Threefold expansion of these facilities can be expected in the next few years.

This dynamic growth has created innumerable openings in all phases of computer design, development, application, test, and customer service. Excellent salaries, employee benefits, and profit-sharing accompany these positions. If you qualify for high standards . . . send your resume to:

R. A. Alexander,
Personnel Director

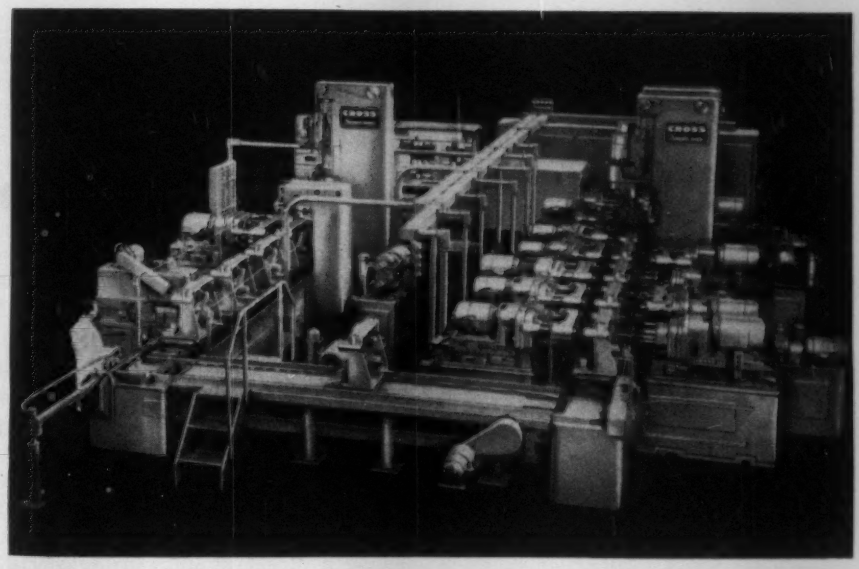
ElectroData CORPORATION
PASADENA, CALIFORNIA

rock radially a slight amount. Immediately upon rotation of spindle, wedge shaped oil films are formed between segments and spindle diameter. They build up to high pressures and automatically adjust themselves to variations in forces created by grinding action. Lubrication of bearings is automatic, with the circulating filtered oil protected by an electrical pressure switch. Automatic grinding wheel balancing is included as standard equipment. Controlled by a lever reached from the operator's normal working position, grinding wheel can be balanced within 20 seconds without removing wheel mount from the machine. Control elements and levers are centrally grouped in front of the machine. Electrical control button, headstock and cutting fluid



and start-stop are also conveniently grouped together on console type control panels. Power table traverse, hydraulically operated, provides infinitely variable traverse rates from 3 inches per minute to more than 200 inches per minute, through a knob control. Length of table traverse may be automatically controlled from the full rated stroke to as short as 3/32-inch. Tarry at each end of stroke may be independently adjusted, from 0 to 5 seconds by means of knob controlled throttle valves. Extra equipment items available include automatic electric gage sizing with continuous automatic compensation, pushbutton automatic infeed attachment, gap eliminator, hydraulic automatic behind-the-wheel profile truing, radius truing, right angle wheel truing, grinding wheel spindle reciprocation and hydraulic footstocks. **Cincinnati Grinders Inc.**, Cincinnati 9, O.

Circle No. **32** *on Reply Card*



No. 33—

Machining Flywheel Housings

Designed to completely machine flywheel housings for both standard and automatic transmissions except for grinding three faces, new machine features automatic selection of setup changes and proper tools at each station. Machine performs 139 operations on 170 pieces per hour, including 49 drilling, 22 chamfering, 4 reaming, 2 counterboring, 30 inspection and 30 tapping operations. Because the parts are irregular in shape, special palletized work holding fixtures are provided. Parts are clamped to the fixtures by hydraulic means. **Cross Co.**, Detroit, Mich.

Circle No. **33** *on Reply Card*

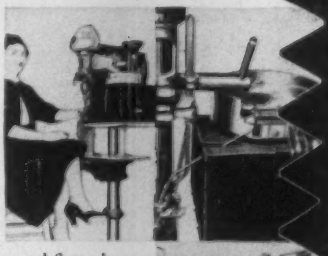
Socket Slotted

SET SCREW

Application 7 Times Faster, New SETKO HOPPER-FED Way

One plant's production rate zoomed from 300 per hour to 2,000 per hour after installing Setko Hopper-Fed Special Equipment* which adapts readily to present machines. Others are making similar gains and getting many additional advantages such as great reduction in cross-threading and floor loss; adaptability to all metals or plastics and smaller set screw inventory.

Arrange for demonstration at our plant, without cost or obligation to you.



Fill in coupon and mail today.

*Pat. No. 2,638,945 Other Patents Pending

Set Screw & Mfg. Co.

266 Main St., Bartlett, Ill. (Chicago Suburb)

We Specialize in Solving Puzzling Set Screw Problems

1160R

COUPON

SET SCREW & MFG. CO., 266 Main Street, Bartlett, Illinois

I would like to have free demonstration of Hopper-Fed Set Screw mechanism at your plant. Please advise particulars.

INDIV. NAME.....

COMPANY.....

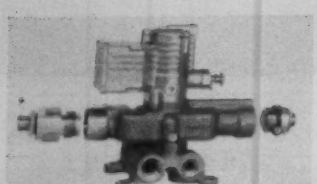
ADDRESS.....

.....CITY.....ZONE...STATE.....

AUTOMATION new components

Parts, elements and devices designed for creating more automatic systems

For detailed information and literature, use card page 115



No. 34—

Cylinder Speed Control

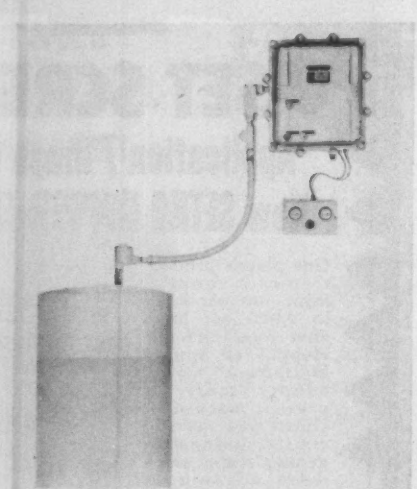
New arrangement adds speed control feature to company line of solenoid pilot operated valves. Restriction of flow through the main control valve, the Speed King, eliminates need of separate flow control valves to control the speed of a cylinder. Control of the restriction through the main control valve is done by the addition of adjusting screws in the end caps which will restrict the stroke of the main stem of the valve and thus restrict the flow of cylinder exhaust air through the valve. Valves with built-in speed control and conversion kits are available for four-way foot mounted and subbase mounted, single and double solenoid, in ¼, ⅜, ½, ¾ and 1-inch sizes. Units will also be available as a kit to convert those valves already in service to speed control. **Valvair Corp.**, 454 Morgan Ave., Akron 11, O.

Circle No. **34** *on Reply Card*

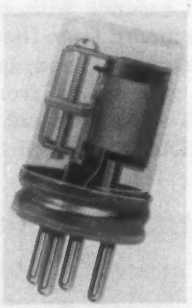
No. 35—

Recorder Controller

Designed primarily for measurement and control of levels of liquids, granular solids, interface and other conducting or nonconducting substances, self balance recorder-controller may be used for other process variables, such as moisture content or composition, which cause a direct change in dielectric control. Electrical and pneumatic control forms can be incorporated within single housing of unit which is accurate within a fourth of one per cent. Instrument consists of a capacitance bridge, one leg of which is the capacity under measurement; opposing leg is motor driven rebalance capacitor. Unbalance signal is fed to phase sensitive demodulator and converted into a 60-cycle unbalance signal. Signal is amplified and used to drive servomotor in such a direction as to reduce unbalance to zero. Radio frequency is used for measurement to reduce reactance of measured capacitance to a value which will not be affected by value of leakage resistance normally encountered. **Fielden Instrument Div., Robertshaw-Fulton Controls Co.**, 2920 N. Fourth St., Philadelphia 33, Pa.



Circle No. **35** *on Reply Card*



No. 36—

Frequency Relay

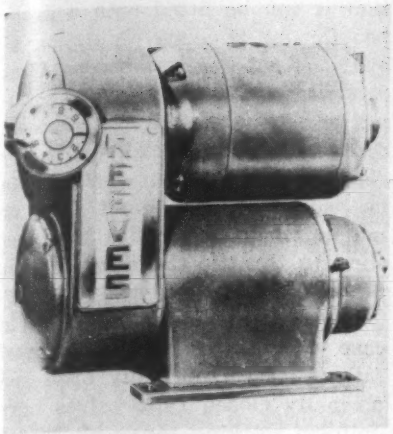
Maximum of ten standard relays may be installed in a control panel, each operated by a signal to which it is tuned. Each in turn operates an auxiliary relay for closing or opening any circuit. Standard equipment on new relay is 400 ohm coil. Frequency range is from 40 to 170 cycles per second. Other frequency ranges are available for special applications. **Potter & Brumfield**, Princeton, Ind.

Circle No. **36** *on Reply Card*

No. 37—

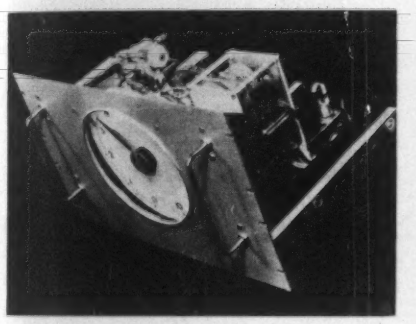
Variable Speed Drive

Designed for 1 hp applications, variable speed unit will meet exacting industrial standards of size, versatility and application. Called Motodrive, unit combines weatherized motor, speed-changing mechanism and heat treated helical gear speed reducer where required. Motodrive is available in speed ranges from 2 to 1 through 8 to 1 and can be obtained in any one of 112 assemblies to meet exact space requirements. One feature of variable speed drive is spiral groove lubrication system. Threaded spiral groove



lubrication assures complete coverage of lubricant over all sliding surfaces. In case of excessive lubrication, overflow outlet carries excess lubricant away from disk faces and V-belt. Vertical model measures 11½ by 16 5/16 by 21½ inches. **Reeves Pulley Co.**, Columbus, Ind.

Circle No. **37** *on Reply Card*

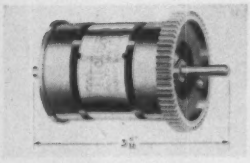


No. 38—

Process Converter

Designed as a high speed, high accuracy digitizing link for automatic logging and automatic input to digital computers and process controls, compact analog-to-digital converter is called the Digi-Coder. Unit converts any process variable that can be represented by an electrical signal into a form suitable for directly operating electric typewriters, digital printers, tape or card punches, lamp banks or for initiating process control. High speed—as many as five readings per second—plus high accuracy—±0.15 per cent of full scale on all readings—make the unit a building block for industrial data reduction and automatic control centers. Unit couples a self-balancing potentiometer to a basic Digi-Coder. Input signals of dc voltages, representing temperature, pressure, flow, acidity or any other process variable—are amplified by dc chopper type amplifier and then fed to a null-balance potentiometer. Potentiometer servomechanism supplies discrete shaft positions to the Digi-Coder section of the device. Digi-Coder converts shaft positions into discrete electrical contact combinations by mechanical means without use of brushes, intermittent transfer gears, relays or transfer switches. Contact closures in Digi-Coder generate coded electric outputs suitable for operating digital readout and control devices. Output can be in decimal, binary, binary-decimal, teletype or any special digital code. Electrical analog input voltage span may be any dc signal varying between 0 to 1 mv up to 0 to 1 v dc. Voltages emanating from nonlinear primary elements such as thermocouples, radiation pyrometers or thermal converters are linearized automatically and digitized in direct reading units. **Fischer & Porter Co.**, Hatboro 35, Pa.

Circle No. **38** *on Reply Card*

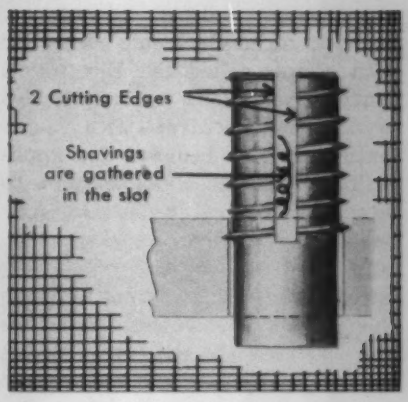


No. 39—

Miniature Differential

Designed for differential applications where small size and long life are essential, miniature units combine two rotating inputs to give speed sums or differences and angular sums or differences. They are also well suited for controlling relative speeds, for obtaining wide speed ratio between shafts, for shifting phase angles between rotating shafts and for reversing and changing speeds without disconnecting power source. Thirty-four different ratios from 1 to 1 up to 27 to 1 provide wide design possibilities. Units with an internal antibacklash feature are also available. **Metron Instrument Co.**, 432 Lincoln St., Denver 3, Colo.

Circle No. **39** *on Reply Card*

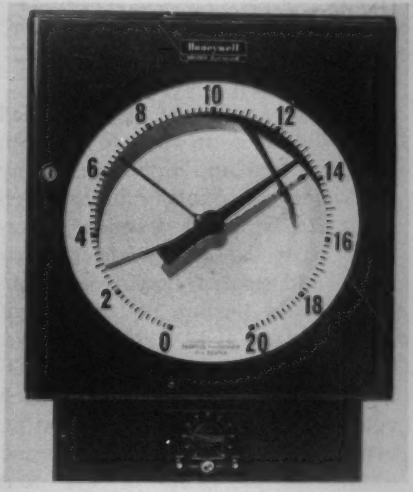


No. 40—

Self-Tapping Set Screw

By eliminating the tapping operation, new self-tapping set screw saves extra cost of taps, saves time and helps cut production cost. In addition to being self-tapping, set screws are self-aligning and self-locking, yet easily removed when desired. Cutting thread extends only around the top or slotted section and offers two cutting edges, enabling it to cut on both sides of the hole. Shavings, instead of accumulating below, are gathered in the slot. It can be supplied with any type set screw point, and is applicable on metal or plastic products. **Set Screw & Mfg. Co.**, 266 Main St., Bartlett, Ill.

Circle No. **40** *on Reply Card*



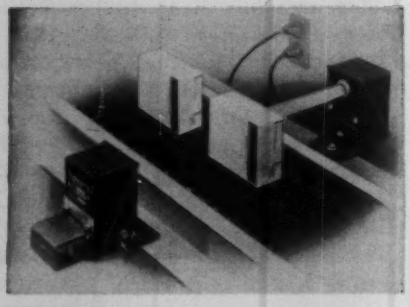
No. 41—

Furnace Control System

Designed to regulate automatically the operation of saturable core reactors used with resistance, high-frequency or induction furnaces,

proportional control system is made up of an electronic controller with a unit called the Electrovolt controller. System, which provides proportional control with automatic reset, is designed for applications where it is undesirable to interrupt current for control purpose. In operation, reactor regulates electrical current to the furnace. Initially this current is fed to the reactor by power amplifiers and boosted to a level strong enough to operate the reactor. To provide necessary control, electronic controller and Electrovolt unit measure temperature and any deviation from desired control point and send a dc signal to a power amplifier which in turn causes the reactor to vary the power source fed to the furnace. **Minneapolis - Honeywell Regulator Co.,** Industrial Div., Wayne & Windrim Aves., Philadelphia 44, Pa.

Circle No. **41** *on Reply Card*

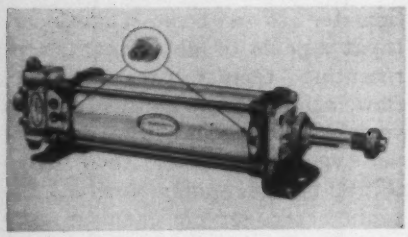


No. 42—

Photoelectric Counter

Reliable counting is afforded with distances up to 8 ft between counting eye and light source by photoelectric counting unit. Each object to be counted should interrupt light beam 1/16-second or more, and space following each object should permit restoration of light beam of 1/16-second or more. Cases are of cast aluminum, gasket sealed and tapped for ½-inch conduit. Adjustable mounting brackets facilitate positioning and alignment of counting eye and light source. Dimensions of counting eye and light source are the same: height, 5⅜ to 6½ inches, depending on bracket adjustment; width, 3 9/16 inches; depth, less bracket, 3 17/32 inches. **Autotron Co.,** Box 722-RR, Danville, Ill.

Circle No. **42** *on Reply Card*

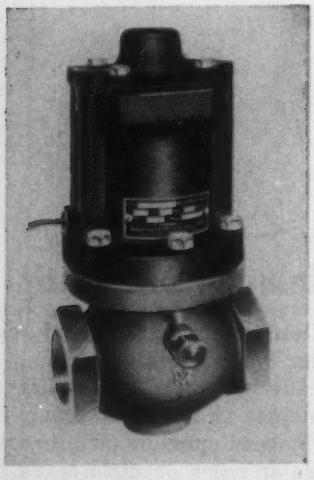


No. 43—

Cushioned Air Motor

Addition to air cylinder line is 2½-inch bore air motor with adjustable cushioning at either or both ends. Unit features built-in four-way valve and speed controls. Valves are available for 8 v or 110 v momentary contact electrical control, including explosion proof models; 110, 220, 440 or 12v maintained contact control; direct mechanical or manual control; air-pilot valve control; and air poppet valve control. Operating at air pressures as high as 175 psi, motor develops a thrust equal to five times the air pressure applied. Cushioning is effective on final ¾-inch of the stroke. **Bellows Co.,** Akron 9, O.

Circle No. **43** *on Reply Card*

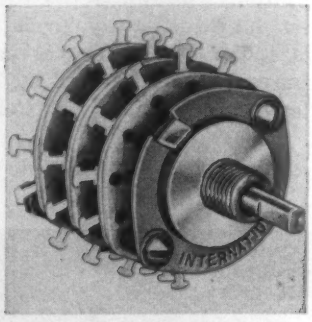


No. 44—

Solenoid Valve

Electrical control of heavy hydraulic machinery such as lifting platforms, hoists, presses, freight and passenger elevators and dumb waiters is possible with packless solenoid valve. Designed for use with soluble oil, hydraulic oil or water at fluid temperatures up to 212 F, valves are of the piloted piston type. Feature of valve is that it can be fitted with a dashpot for independent regulation of opening and closing speeds. Vent screw in valve body adjusts opening speed; vent screw in dashpot controls closing speed. Normally closed valves without dashpot can be supplied with hand lift for manual control or with metering stem to throttle the flow. Metering stem can be used also for emergency return of an elevator in case of mechanical or electrical failure. Both normally open and normally closed type valves have uniform working range of 300 psi maximum. **Magnatrol Valve Corp.,** Hawthorne, N. J.

Circle No. **44** *on Reply Card*

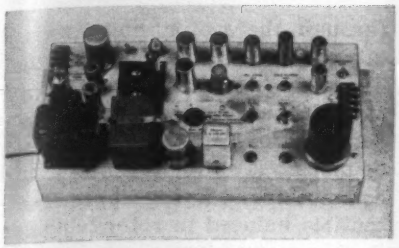


No. 45—

Rotary Switches

Designed for use on electric and electronic testing equipment, miniaturized and transistorized devices and other applications where saving space is important, low-current, subminiature rotary switches are 1.6 inches in diameter including contacts. Switches offer 12 stator positions per deck, exclusive of poles. Standard contact arrangements are from one pole, 12 positions to four poles, three positions. One, two, or three decks can be supplied with continuous rotation with single pole or stops for multipole operation. Construction feature is wafer of specially impregnated glass melamine which has high humidity resistance and is very tough but not brittle. Solder type lugs are included on wafer's connection ends for ease in wiring. Contact resistance is 0.015 ohm; dielectric strength 1000v rms minimum. Current carrying capacity is 1 amp at 50v dc. **International Instruments Inc.,** New Haven, Conn.

Circle No. **45** *on Reply Card*

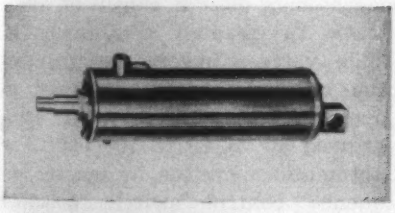


No. 46—

Telemeter Terminals

Quantities which can be converted into dc millivolts through use of a transducer or primary detector are accurately and instantly telemetered by frequency type telemetering terminals. Transmitter converts the dc millivolts to an ac signal which in turn frequency modulates an included audio tone channel. Receiver converts audio tones to dc millivolts which may then be used to operate a recorder or indicating instrument. Design of channeling equipment insures accurate and reliable telemetering over all communication channels even when operating in presence of noise and varying signal levels. At least 45 individual channels are available in frequency range of 765 cps to 20 kc. Protective circuits are included which will prevent reverse current in output circuit in the event of signal failure, and erroneous readings when operating with below minimum input levels. **Radio Frequency Laboratories Inc.,** Powerville Rd., Boonton 33, N. J.

Circle No. **46** *on Reply Card*

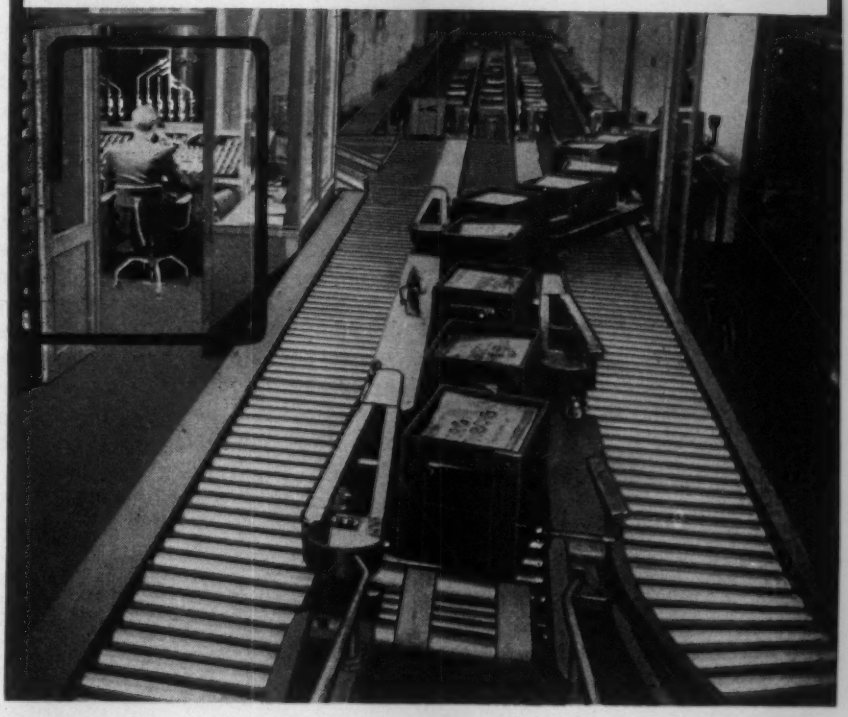


No. 47—

Hydraulic Cylinders

Designed for use in farm and road building machinery, dump truck hoists, arbor presses, aircraft maintenance hoists, materials handling equipment and mining machinery, hydraulic cylinders feature large diameters. Units are available in 5, 6, 7, and 8-inch bore sizes. Cylinders are heavy wall, seamless steel tubing bored

1 MAN ALONE OPERATES PLANTWIDE A-F ENGINEERED CONVEYING SYSTEM



Just 1 man, sitting at the control panel shown above automatically controls the *starting* and *stopping* of *all* or *part* of this A-F Engineered Completely Co-ordinated Conveying System. He also routes and switches "trains" of cases on 5 A-F Conveyor lines to 2 groups of loading docks . . . Cases are automatically counted as they are being moved . . . Visible and audible signals prevent traffic jams . . . Before you order any type of conveyor, better write us. We'll be glad to submit an estimate.

A-F

YOU CAN SEE THE SUPERIORITY OF A-F CONVEYOR ENGINEERING

A-F *Engineered* Conveyors
Custom Engineered Conveying Systems
Pre-Engineered Conveyors—Wheel, Trolley
Metal Cleaning and Processing Machines

THE ALVEY-FERGUSON CO., 170 Disney Street, CINCINNATI 9, OHIO and Azusa, Cal.

and honed to a precision finish. Units cover a range up to 36 tons at working pressures from 1000 to 1500 psi. Cast iron pistons and rings with V-type packing and easily adjusted glands are standard equipment. Single or double-acting, cylinders are available with threaded, plain or pin eye rod fittings and cylinder mountings. **Wisconsin Hydraulics Inc.**, 3165 N. 30th St., Milwaukee 16, Wis.

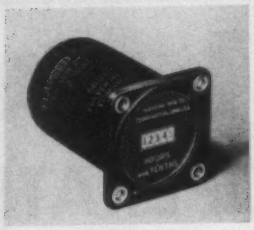
Circle No. **47** *on Reply Card*

No. 48—

Voltage Source

Designed to replace the chemical cell and voltage reference tube as an absolute reference, constant output working supply, or precision voltage regulator in airborne, laboratory and other instrumentation requiring extreme stability over widely varying environmental and operating conditions, voltage source is available in models for operation from either an ac or dc source. Unit provides constant dc output through ambient temperatures as low as −55 and up to 100C. Design of unit utilizes voltage regulating network based upon special types of double anode silicon diodes selected for stability of conduction characteristics. Using neither tubes nor moving parts, it is unaffected by position, vibration or mechanical shock. Uniformity of output is maintained through repeated *On-Off* switching. Voltage source is available for operation from 26.5 v dc, or 117 v ac, with dc output of 6 v, or 1 v, at 1 ma or 10 ma. Other features include life expectancy in excess of 10,000 hours and random drift less than 0.1 per cent over 1000 hours of operation. **Avien Inc.**, 58-15 Northern Blvd., Woodside 77, N. Y.

Circle No. **48** *on Reply Card*

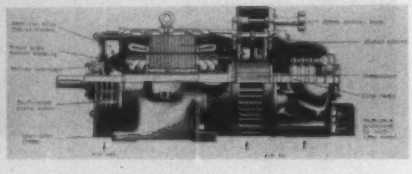


No. 49—

Time Totalizer

Direct reading elapsed time indicator is commercial variation of 115 v, 400 cycle hermetically sealed elapsed time indicator recently announced to avionic equipment and engine suppliers. Running time meter is available in dust-tight case with synchronous motor drive. Precision five-digit counter accurately registers accumulated hours of equipment operation. It is designed for use on 115 v, 60 cycle, ac. Two models are available: one indicates hours in 0.1-hour steps to 9,999.9; other indicates minutes in 0.1-minute graduations to 9,999.9 minutes. Units measure 1½ inches in diameter by 2¾ inches long, and mount in front or behind mounting panel. **Haydon Mfg. Co. Inc.**, 245 E. Elm St., Torrington, Conn.

Circle No. **49** *on Reply Card*

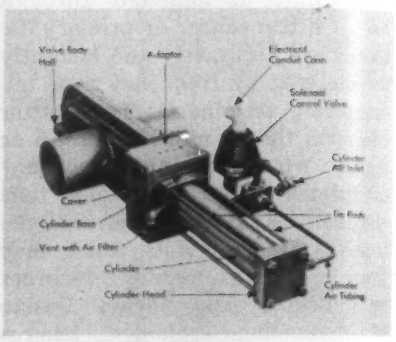


No. 50—

AC Motor

Adustable speed ac motor with no external controls is used in textile and plastics industries, variable load conveyors, automatic stokers, paper making machinery, and chemical processing. They are also expected to find extended uses in metalworking industry. Completely self-contained, motors use Schrage principle for stepless control from 0 to 2400 rpm, with torque approximately constant at all speeds. They need no gearboxes, resistors or other external devices to vary speed. Ratings range from ½ to 75 hp, for 220 or 440v, 60-cycle, three-phase power supply. Large radial fan draws air in at the front, circulates it through the motor, and expels it at drive end to avoid recirculation. There are no losses from a rheostat, friction drive or power converter. Control knob varies speed of motor; it shifts brushes around commutator, varying opposing potentials induced in rotor windings. Servo motor can replace knob. **ACEC Electric Corp.**, 40 E. 49th St., New York 17, N. Y.

Circle No. **50** *on Reply Card*



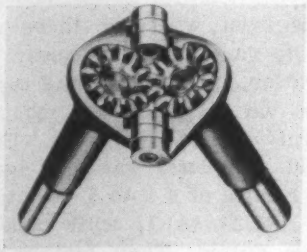
No. 51—

Segregating Valve

Designed for pneumatic materials handling systems, slide gate type segregating valve can be used for manual or automatic operation. Valve can be installed either in branch lines to cut off inactive portions of system, or at other points in the system where it is desired to isolate a portion—such as between a cyclone collector and vacuum source to permit periodic discharge to a storage bin. Designs of operating mechanism offer a choice of automatic or manual positioning of slide valve. In one design, piston type air cylinder is used to open or close valve with compressed air at 80 to 100 psi. For automatic operation by master sequence control switch, solenoid pilot valve is used to admit supply of compressed air to the cylinder. Incorporation of segregating valve in a handling system provides tight closure of all inactive branches of a line. In pneumatic systems where cyclone collector is employed to discharge material to a storage bin, segregating valve is closed during each dumping period. This improves discharging operation in two ways: when vacuum is cut off from cyclone, atmospheric air fills voids between particles of ma-

terial, thereby aiding the discharge; and extremely fine particles which are released by upward surges during dumping operation will not be drawn into vacuum producer. Assembly consists of the valve body and attached operating mechanism. **Allen-Sherman-Hoff Co.**, 259 E. Lancaster Ave., Wynnewood, Pa.

Circle No. **51** *on Reply Card*



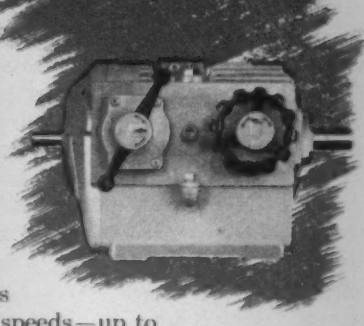
No. 52—

Hinged Gear Joint

Designed primarily for use on hand-operated remote controls, hinged gear joint is also well suited for use on out-of-line power transmissions up to ¼ hp at speeds not exceeding 1750 rpm. Used in multiples of two or more, it provides an almost unlimited assortment of power transmission possibilities. Joint operates smoothly in most applications where power must be angled to any position from 3 to 140 degrees away from a straight line. There is no need to shut off or reduce speed or power transmission during the wide swing. Produced originally as a component to be used in remote control of glass bottle making equipment, joint is now designed for use on three shaft sizes: 7/16, ½ and 9/16-inches, and with an overall length of 10¼ inches. Primary link in its power train is two bevel gears which have been modified to mesh smoothly and consistently through the full 137-degree arc despite a constantly changing relationship between pitch line and axis of each gear. When in fully closed position—when the axes are only 3 degrees from a straight line—all teeth in gears are meshed. In fully open position, four teeth are engaged. **Gray & Prior Machine Co.**, 614 Windsor St., Hartford, Conn.

Circle No. **52** *on Reply Card*

If you could hire a Gnu...



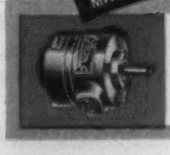
The ungainly Gnu is considered to be a most flexible beast. He has six speeds forward, can make prodigious leaps, can turn on a dime, and even back-up at an acceptable speed. However, the Gnu has to take a back seat in the flexibility department to the new GEROTOR VARIABLE SPEED HYDRAULIC TRANSMISSION. This new transmission has infinitely variable speeds—up to 1500 rpm—in *either* direction, can reverse itself instantly, has completely self-contained controls, can be mounted easily with standard motor to fit just about any situation. Better cancel your plans to hire the Gnu and make rapid inquiries about the new GEROTOR VARIABLE SPEED HYDRAULIC TRANSMISSION . . . *write:*

GEROTOR

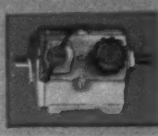
MAY CORPORATION

MANUFACTURERS OF—

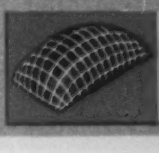
1541 MARYLAND AVENUE, BALTIMORE 3, MARYLAND



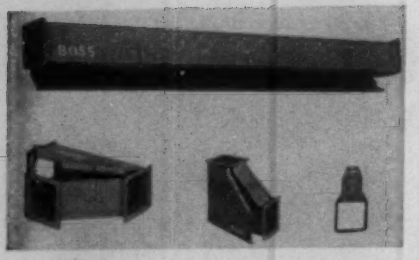
Hydraulic Pumps and Motors



Variable Speed Hydraulic Transmissions



PneuBin—Pneumatic Bin Evacuators

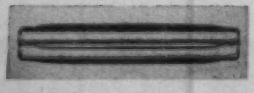


No. 53—

Electrical Wireways

Both flanged and flangeless wireway are included in line of electrical wireway and fittings for assembly of completely electrical wireway systems. Three sizes of flanged wireway are available in new line: 2½ by 2½ inches, 4 by 4 inches and 6 by 6 inches. Flanged units are equipped with knockouts on three sides, full length hinged covers, and may be easily clamped together. They are available in lengths from 1 to 5 ft. Flangeless wireway, available in four sizes, has easily attached screw-on cover. Cover may be taken off without completely removing holding screws. Wireway clamps together with U connectors. Special adaptors are supplied where flanged and flangeless wireway are to be used in a single wiring system. Flangeless line is available in sizes of 2½ by 2½ inches, 4 by 4 inches, 4 by 6 inches, and 6 by 6 inches, and in lengths to 5 ft. For both types of wireway, line includes complete selection of accessory fittings: 45 and 90-degree elbows, T-fitting pull boxes, closing plates, etc. For flanged wireway, telescoping fittings, nipples, junction boxes and hangers are also included. **Huenefeld Co.**, 2702 Spring Grove Ave., Cincinnati 25, O.

Circle No. 53 on Reply Card



No. 54—

Self-Locking Pin

Designed for hopper feeding and insertion in a drilled hole, self-locking pin features a pilot on each end, permitting fast insertion and easy, accurate starting of either end of the pin. Pin is provided with full length grooves to give maximum locking effect along entire grooved length of the pin. It is used as a substitute for taper pins in keying sprockets, gears, collars, knobs, handles, levers and wheels to their shafts. Parallel, equally spaced grooves are impressed on shank of pin, displacing a predetermined amount of metal to each side of the cut to form a raised flute. When the pin is driven into a hole of the same diameter as the shank, flutes are compressed against the hole wall, creating a large radial holding force. Pins are available in a wide range of sizes and materials. **Driv-Lok Pin Co.**, Sycamore, Ill.

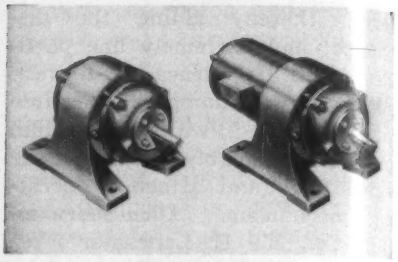
Circle No. 54 on Reply Card

No. 55—

Bakelite Condenser

Designed for automatic insertion into a printed circuit board, bakelite case condenser has two parallel lead wire terminals which are brought out from the same end. Bakelite housing is molded to precise tolerances. It is tubular in shape and one end is sealed. Capacitor section which may be paper or mylar is inserted and the leads accurately positioned. An epoxy resin is then poured into the opening. When resin is set, no moisture can reach the capacitor section and leads are firmly supported. Capacitors will withstand high temperatures, have high insulation resistance, are extremely rugged to shock, vibration and handling, and contain no outer wax that can drip off onto the printed circuit chassis. Condensers can be furnished in many diameters and in any lead size and lead length. **Chicago Condenser Corp.**, 3255 W. Armitage Ave., Chicago 47, Ill.

Circle No. 55 on Reply Card

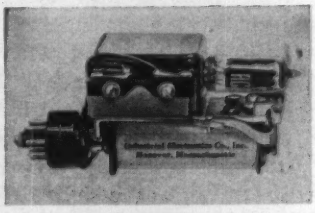


No. 56—

Motor Induction Drives

Applications for motor induction drives exist wherever there is a need to vary speed, to control acceleration, deceleration and torque on a variety of loads requiring careful speed regulation. Units provide stepless, variable speeds over ranges of a 2 to 1 ratio to as high as 34 to 1, with constant torque output. They feature fast response, maintain accurate rpm and require a minimum amount of maintenance. Motor sizes start at ¾ hp at 3400 rpm and extend to 75 hp at 1700 rpm. Where loads fluctuate or input frequency varies, fixed rpm of high accuracy are insured by automatic regulating device. This senses variations in the output shaft rpm and compensates by increasing or decreasing dc excitation to induction coupling. Output shaft is thus maintained at any desired rpm within ± 2 per cent of top speed, or can even be controlled within 0.25 per cent of top speed where extreme regulation is necessary. **American Electric Motors Inc.**, 2112 Chico Ave., El Monte, Calif.

Circle No. 56 on Reply Card



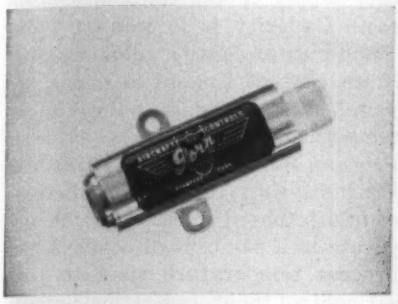
No. 57—

Electronic Relay

Applicable as a level control for filling containers, as a precision temperature or pressure controlling device, and for measuring movements of delicate devices, highly sensitive relay is capable of operations on less than 15 mil-

lionths amp. Electronic relay has power amplification of approximately 10 million to one. Input power to the unit is less than 0.0011 w, while output circuit can carry up to 1150 w. **Industrial Electronics Co. Inc.,** Hanover, Mass.

Circle No. 57 on Reply Card

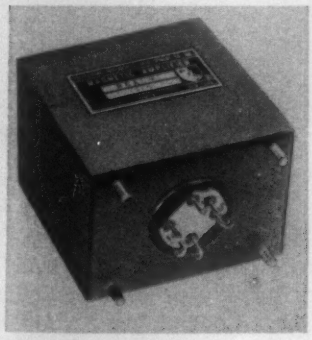


No. 58—

Pressure Switches

Applicable for control of aircraft, missile and industrial systems, 4-oz, compact pressure sensitive device may be set to respond to hydraulic or pneumatic pressures of 100 to 12,500 psi. It is particularly suited where reliable performance is required under severe vibration, acceleration and adverse environmental conditions. Switches are adaptable to many mountings or envelope specifications. **Aircraft Controls Div., Gorn Electric Co. Inc.,** Stamford, Conn.

Circle No. 58 on Reply Card



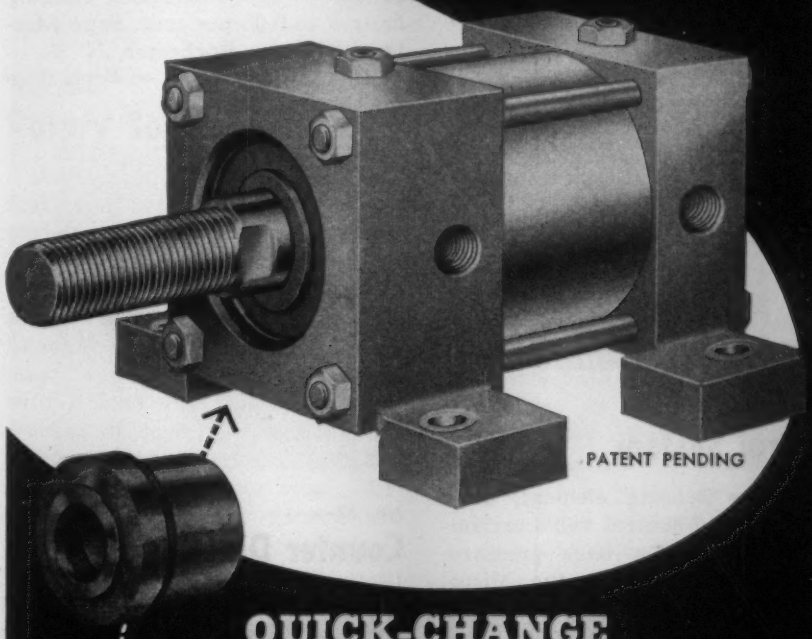
No. 59—

Magnetic Amplifier

Low level, push-pull dc magnetic amplifier is designed to amplify output of low level devices such as thermocouples, strain gages, thermistor bridges, phototubes or crystal detectors so as to operate

SP

*APPROVED HEAVY-DUTY AIR CYLINDERS for Automation



QUICK-CHANGE PACKING CARTRIDGE Cuts Downtime

Step up production with rugged, service-free, S-P Heavy-Duty Air Cylinders:

- Designed for 200 PSI
- Rolled steel end plates
- Extra long cushions
- Extra large, hardened piston rod
- Minimum mounting and envelope dimensions
- 5 types of mountings
- 8 bore sizes, 1½" to 6"
- Double porting
- Interchangeable check and cushion valves
- Quick-change packing and bearing cartridge

* S-P Automation Cylinders were designed expressly for a large automobile manufacturer. They are thoroughly proven for automation and general heavy-duty applications. Prompt deliveries. Send for Catalog 109. For S-P standard Air Cylinders, request Catalog 102. The S-P Manufacturing Corp., 12415 Euclid Ave., Cleveland 6, Ohio.

SP

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A Bassett Company
PRECISION PRODUCTS SINCE 1916
AIR AND HYDRAULIC CYLINDERS • POWER CHUCKS • ROTATING AIR CYLINDERS
COLLET AND DRILL PRESS CHUCKS • AIR PISTONS, VALVES AND ACCESSORIES

an insensitive relay or meter. Amplifier is self-contained and requires no external rectifier. Unit will provide push-pull dc output for reversible polarity dc signal input. Stability and linearity are good within ambient temperature rating of −55 to 85 C. Units can be cascaded for increased gain. Magnetic amplifier is hermetically sealed and highly resistant to shock and vibrations. **Polytechnic Research & Development Co. Inc.**, 202 Tillary St., Brooklyn 1, N. Y.

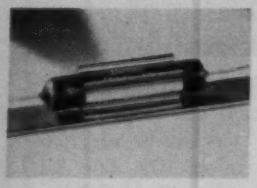
Circle No. **59** *on Reply Card*

No. 60—

Control System

Pressure sensing element, control pilot and control valve are incorporated in new back pressure control system called the Micro Delta P Controller. Pressure controller provides square-wave pressure response, microsecond control and constant pressure throughout full flow range. Controller is development in company program to bring advanced techniques to testing and control apparatus for hydraulic, pneumatic, electric and electronic fields. **Industrial Engineering Corp.**, 525 E. Woodbine, Louisville 8, Ky.

Circle No. **60** *on Reply Card*



No. 61—

Silicone Resistors

Clip mounting is feature of new silicone coated resistors. Coating is hard and durable and will not crack, chip or peel when resistor is pressed into the clip. Quality of coating change is not affected by high ambient temperatures. Clip mounting of miniature wire-wound resistors offers advantages where vibration or large accelerations are inherent. In addition, because part of the heat is dissipated through base of the clip into the chassis on which it is mounted, more power may be gained, depending upon mounting location and environment. Line of resistors includes seven dimensions with ratings from 2 to 10 w and tolerances ranging from 3 to 0.05 per cent. **Sage Electronics Corp.**, Rochester, N. Y.

Circle No. **61** *on Reply Card*

No. 62—

Counter Dial

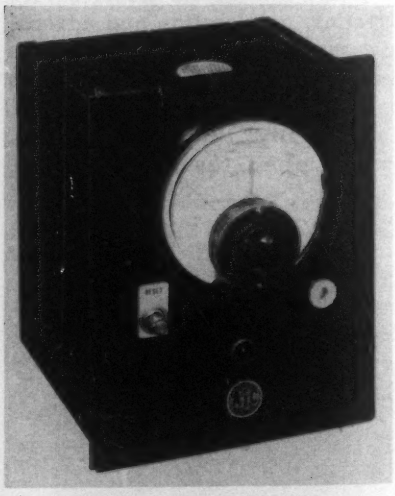
Designed for use with multiturn devices such as potentiometers, microwave oscillators and amplifiers, wavemeters, or any other hand or servo operated mechanism where direct reading to hundredths of a turn is desired, direct reading counter dial allows complete continuous rotation without obstruction. Dial has a driving ratio of 1½ to 1. It has four-digit counter and affords readings up to 9999, with up to 100 turns. Compact counter dial is made of black anodized aluminum, measuring 2¼ inches in diameter and 1¾ inches in depth. **Amerac Inc.**, 116 Topsfield Rd., Wenham, Mass.

Circle No. **62** *on Reply Card*

No. 63—

Contact Controller

Temperature indicating, electronic contact controller automatically holds and controls process temperatures as high as 2500F to within ±1 per cent of scale. It provides both straight cutoff and simple *On-Off* control as required for industrial furnaces, ovens, tanks, or similar types of production equipment and machinery where temperature control is vital to product uniformity. Instrument consists of two separate units housed together. Pyrometer unit indicates temperature under control up to the control point, and an electronic control unit opens and closes load relay regulating fuel supply to the controlled process. Capacity is 5 amp at 115v. Temperature setting pointer with three contact fingers is moved by panel dial to scale point where temperature control is desired. Process temperature is registered by indicating pointer of thermocouple-actuated millivoltmeter accurate to 2 per cent of scale. When process temperature rises to preset control point, indicating pointer makes contact with setting pointer and control action starts. Input impedance is changed; a primary relay in the plate circuit of a vacuum tube releases its armature; load relay drops out, shutting off process fuel supply. When process temperature drops below the control point, indicating pointer moves clear of contact fingers; input impedance rises; control action reverses turning process fuel supply back on. Control band width is 1 per cent of scale or less, depending on the process. Flick-switch located inside case gives choice of cutoff or *On-Off* type of control. Unit is available in five ranges: 0 to 600, 1000, 1500, 2000 and 2500 F. **Automation Instrument Corp.**, 1516 Summer St., Philadelphia 2, Pa.

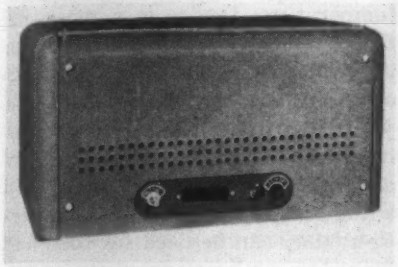


Circle No. **63** *on Reply Card*

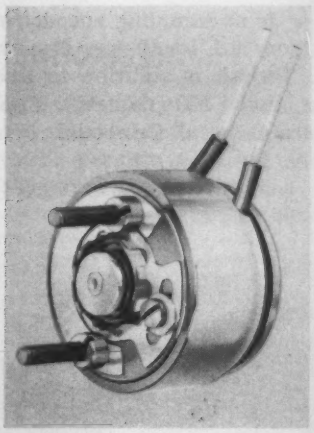
No. 64—

Voltage Regulator

Applicable to unattended installations requiring dependable automatic line regulation, tubeless ac line voltage regulator offers extremely stable performance over long periods with a minimum of maintenance. Regulator uses a magnetic amplifier controller circuit with a silicone diode reference element, and is basically insensitive to frequency variations. Output load range is 0 to 1000 va; input frequency range is 55 to 65 cycles. Regulation accuracy is ±0.5 per cent against line or load. **Sorenson & Co. Inc.,** 375 Fairfield Ave., Stamford, Conn.



Circle No. **64** *on Reply Card*

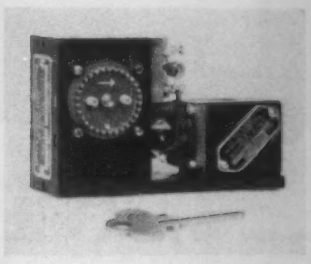


No. 65—

Rotary Solenoids

Adjustable return spring is the feature of rotary solenoid. Spring permits minute spring torsion adjustments. Any return spring torque can be set within limits of spring design. Feature is desirable in applications where return spring must return solenoid armature with a load and where close tolerances of spring settings are required. Return spring is installed in a movable retainer ring. Adjustments of spring torsion are accomplished by rotating retainer ring to proper position, after which it is locked in place by a set screw. **G. H. Leland Inc.,** 123 Webster St., Dayton, O.

Circle No. **65** *on Reply Card*



No. 66—

Rotary Sampling Switch

Designed for use in airborne and general instrumentation applications, new line of small and lightweight rotary sampling switches with integral dc drive motor is available with 1, 2, 3, or 4 poles containing 24, 30 or 32 shorting contacts per pole. Phasing between poles can be manually adjusted while switch is in operation. Motor voltages of 6, 12, or

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RELAYS

Reduce Assembly Costs!

Whether your design calls for a large open relay or a miniature sealed one, P&B can supply it with any type of mounting or termination you desire. P&B's engineering foresight has anticipated your assembly problems; designing, versatility and flexibility into each of their relay types.

Let our engineering group with a quarter century of relay "know how" become part of your design team.

Send your specifications for recommendations and quotations.

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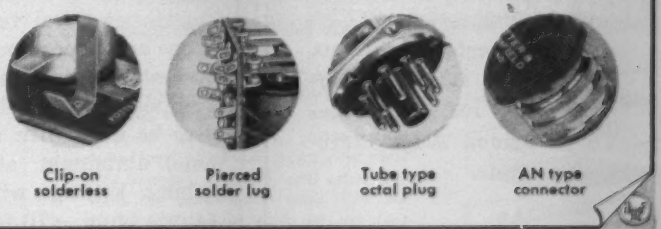


Clip-on solderless

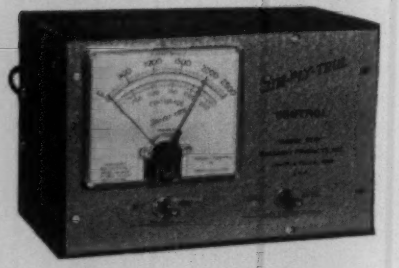
Pierced solder lug

Tube type octal plug

AN type connector

(Advertisement)

SIMPLYTROL AUTOMATIC PYROMETER



Cat. No. 4531 0/2500° F.
Price $132.00

Thermocouple type Automatic Pyrometer for controlling temperature in furnaces, ovens, and processes. The Simplytrol is economical and reliable with few moving parts. There are no vacuum tubes. The regular load relay is S.P.D.T. 5 Amps. Optional heavy duty relays to 40 Amps.

10 temperature ranges cover from —75° to 3000° F. Several special ranges to —400° F. "On & Off" control for holding the desired temperature works on gas, oil or electric heat. Indicating meter-relay is medium high resistance and has bimetal cold junction compensation. For use with all standard thermocouples. Accuracy 2%.

"Auto-Limit" switch changes Simplytrol from automatic controller to limit pyrometer for safety shut down or warning. Cabinet: 6½x6½x9½ inches. Also flush panel mount models. Send for new Bulletin G-7 for more data. Assembly Products, Inc., Chesterland 27, Ohio.

ENGINEERS

Available or Wanted

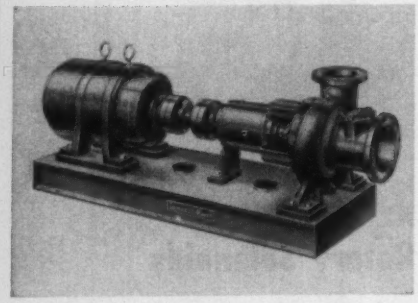
AVAILABLE: Senior Designer. 20 years experience. Paper making, coating, laminating, converting, automatic winding, aniline and rotogravure printing machinery. Fox River Valley, Wisconsin. Address Box 102, AUTOMATION, Penton Building, Cleveland 13, Ohio.

•

AVAILABLE: Chief Designer. 15 years specializing in wrapping machinery. Have original designs and will consider new enterprises. Fox River Valley, Wisconsin. Address Box 103, AUTOMATION, Penton Bldg., Cleveland 13, Ohio.

27.5 v dc at sampling speeds ranging from 0.1 to 10 rps are available. Switch is addition to line of more than 200 models. **Applied Science Corp. of Princeton,** Princeton, N. J.

Circle No. **66** *on Reply Card*



No. 67—

Centrifugal Pump

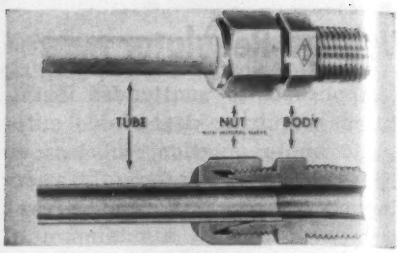
Paper stock and industrial liquids pump can be used in pulp and paper mills to handle stock at concentrations as high as 10 per cent, in chemical or food plants to handle liquids containing solids without damage to the products, and in processes requiring injection of large amounts of air into the pump suction. These pumps replace rotary or other positive displacement pumps. Pump features a diverging type impeller which enables it to handle liquids containing high concentrations of solids, air and gases. Diverging type impeller has greater area at discharge than at the inlet. Design prevents vapor binding, avoids clogging and makes the pump self-venting and self-regulating. Pump is horizontal, single-stage unit, built in sizes from 4 to 12 inches, with capacities from 200 to 7000 gpm and heads from 5 to 225 ft. **Ingersoll Rand Co.,** 11 Broadway, New York 4, N. Y.

Circle No. **67** *on Reply Card*

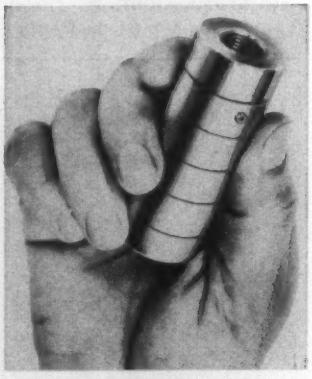
No. 68—

Nylon Tube Fittings

Designed for use with either plastic or metal tubing, nylon fittings are impervious to most acids and alkalis and can be used with stainless steel tubing. They can also be used with nylon, polyethylene, aluminum, steel and copper tubing. Fittings withstand temperatures from —70 to 250 F. Recommended working pressures range from 150 to 500 psi, depending on temperature. Device is a two-piece fitting; sleeve in the fitting is an integral part of the nut. No flaring of the tube is required. To make a joint, it is only necessary for tubing to be inserted into fitting body and nut tightened. Fittings will withstand repeated steam sterilization; they can be used for food and beverage applications. Fittings are available in size range from ¼ to ½-inch OD in unions, bulkheads, half unions, elbows and tees. **Imperial Brass Mfg. Co.,** 1200 W. Harrison St., Chicago 7, Ill.



Circle No. **68** *on Reply Card*

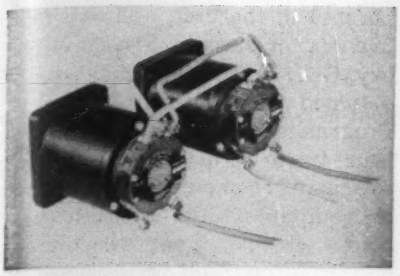


No. 69—

Pneumatic Silencers

Noise-shock is eliminated from air-operated equipment through use of pneumatic silencers. Called Quietaires, units are of all-metal construction. They reduce sound in noise-shock areas close to level found in average factory—75 db. Quietaires have no cartridges, are corrosion-resistant and safe for any pressure normally encountered in industrial pneumatic service. Pneumatic silencers are available in four models and will fit in most industrial air-operated equipment. **C. W. Morris Co.,** 10628 Cloverdale, Detroit 4, Mich.

Circle No. **69** *on Reply Card*



No. 70—

Synchro Torque Unit

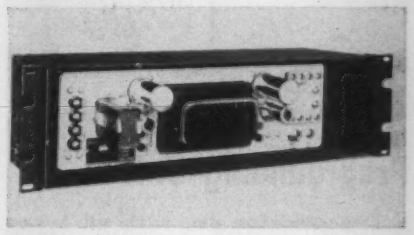
Designed for operation in a parallel circuit with one unit functioning as a driver and the other as a receiver, synchro torque transmitter-receiver is a rugged, long-life unit. The 60-cycle synchro withstands a 2000-hour operating life at 1200 rpm with no maintenance. Pull out torque is 1.7 oz-inch minimum over a speed range of 0 to 1600 rpm at 25C. Electrical accuracy of two-unit system is ±1 degree. Unit has a 115 v input voltage, 17 v maximum output voltage, 3.5 w power input at no load and 0.12 amp current at no load. **Avionic Div., John Oster Mfg. Co.,** 1 Main St., Racine, Wis.

Circle No. **70** *on Reply Card*

No. 71—

Potentiometer

High sensitivity of transmitting potentiometer—better than 3 microvolts—permits accurate control of temperatures when used with company electronic control system. Unit permits measurement and control of low voltages while drawing negligible current from the



source. It is available as a thermocouple pyrometer or to measure dc output of electrical transducers. Potentiometer uses no slidewires, batteries, standard cell, chopper or converter, and has only two vacuum tubes. Input voltage is automatically balanced against output signal by use of balance system which also maintains constant reference voltage supply, accurate to 0.05 per cent without periodic standardization. Transmitter is available in ranges from 6 to 50 mv (200F and up) with zero suppression up to five times the span. Output of 0.5 to 5 ma dc is produced, which can be transmitted over distances up to 30 miles. Speed of response for 10 mv range is better than ¼-second for 90 per cent response. **Industrial Controls Div., Manning, Maxwell & Moore Inc.,** Stratford, Conn.

Circle No. **71** *on Reply Card*

No. 72—

Infrared Analyzer

Designed to continuously monitor and control liquid and gaseous process streams, continuous infrared dispersive type analyzer is well suited for pilot plant operation because of its versatility and easy adaptability in determining material balances and overall yields. Another important application of new instrument is in controlling product purity from fractional distillation column where its use enables greater throughput and more uniform product quality. An example is the analysis of styrene

METZGAR LIVE ROLLER Conveyors

STANDARD WIDTHS 11½" — 15" — 18" — 24". LENGTHS TO SUIT REQUIREMENTS

PACE-SET YOUR PRODUCTION SPEED

Work can be held momentarily for adjustment or inspection without cutting main drive. May be used on slight incline or decline.

An extremely versatile power conveyor when fitted to your needs.

BEST *for*

- Moving sharp-cornered and rough edged items
- Power unit in gravity line
- Production line work movement
- Handling heated and heat treated items

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GRAND RAPIDS 4, MICH.

THE FAST WAY TO FASTER PRODUCTION

"Automation" is not limited to the remote-controlled factory of tomorrow . . .

Nor a new multi-stage transfer machine some time next year . . .

Nor even a completely new, completely automatic production line . . .

In most cases, automation is the application of automatic mechanical assists to trouble spots in existing lines, on existing products. Hoppers to handle, sort, or feed . . . elevators and chutes to connect machines . . . automatic reserve storage to cushion differences in machine rates.

We at KDI are the leading specialists in mechanical automation, and have worked on these problems for the majority of the country's largest manufacturers as well as many small ones.

SORTING
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WEIGHING
CHECKING
PACKAGING

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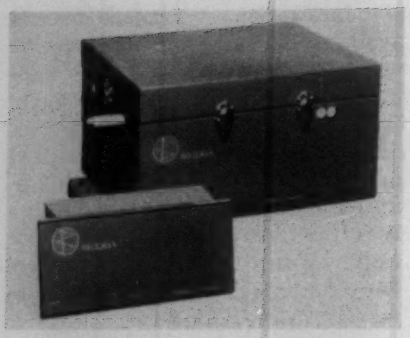
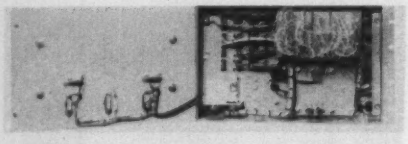
977 EXCHANGE ST., ROCHESTER 8, NEW YORK

As a result of 12 years' experience, and many hundreds of installations, we are able to use already-developed designs—or, even, ship units from stock—in supplying special hoppers, feeders, and other devices for automation now. Call on us for the whole story of the fast way to faster production.



and ethyl benzene that are precisely separated in one of the steps in the manufacture of synthetic rubber. Analyzer combines features of a precise, highly sensitive laboratory spectrophotometer with heavy duty dependability of a commercial instrument. Instrument is made up of three basic components—the detector, amplifier and recorder. Detector, a single beam spectrometer with slit width and wavelength adjustment controls, is enclosed in an explosion-proof case. Double wavelength attachment that can continuously or selectively alternate the wavelength setting between two fixed wavelengths and equip the instrument to monitor two different components in a single process stream is available. Amplifier can be separated by distances up to 300 ft from the detector. Recorder can be either a modified strip chart or circular chart type. **Beckman Div., Beckman Instruments Inc.**, Fullerton, Calif.

Circle No. **72** *on Reply Card*



No. 73—

Programming Unit

Designed for use with all types of digital data recording equipment, programmer operates a typewriter, paper tape punch, or ten-key electrical input adding machine by taking data in parallel form and presenting data in serial form to operate output devices. Control functions are available to control recording devices completely so that desired format can be obtained. Provisions for space, tab and special coding are incorporated in the unit, and any four, five, six, or seven-hole code in binary, Gray or binary decimal can be obtained from output of the unit. Programmer can prepare and present word structure in required format for computer inputs. Unit is equipped with internal plugboard so that input selection or output format can be arranged as required. Relays for conditional transfer of information or control during various portions of operating cycle are included. It is especially useful in operation of devices such as Flexowriter typewriter, IBM typewriter, and various paper tape punches; it can also be used to feed digital information into telemetering equipment and computers. Programmer operates directly from a 115v ac line with a self-contained power supply, and contains an auxiliary power supply for operation of devices such as the IBM typewriter. **Datex Div., G. M. Giannini & Co. Inc.**, 918 E. Green St., Pasadena 1, Calif.

Circle No. **73** *on Reply Card*

1st ADVERTISEMENT

Although we have been in business for 29 years, this our first advertisement in this publication. However, we are well known to readers of other trade journals.

Our principal business is the fabrication of sheet metal products and electronic components, in fact, our sheet metal division makes over 1500 different types and sizes of products as our standard line. These are sold through nationwide distributors.

We also specialize in long and short runs of specially fabricated products for leading manufacturers all over the country for whom we are able to effect economies which result in lower prices and faster delivery.

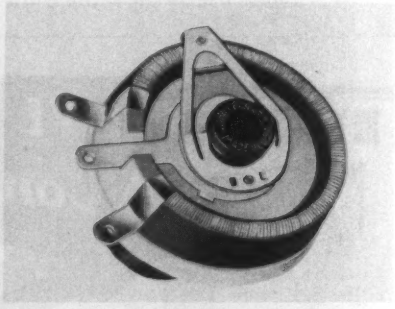
Compare our standard products with those you may have occasion to purchase. We are interested in the opportunity to be of service to you. Write for our latest catalog, it shows our line and describes our service.

Just a few of our products

BOXES • BRACKETS • CABINETS • CASES • CHASSIS • CHOKES • CONDENSERS • COUPLINGS • METER CASES • METER PANELS • PANELS • RACKS

BUD RADIO, INC.

2118 East 55th St. Dept. A. Cleveland 3, Ohio



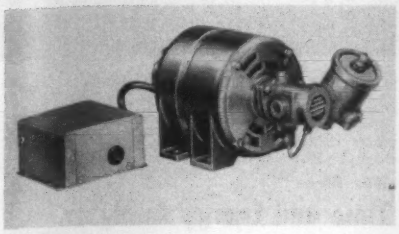
No. 74—

Ring Type Rheostat

Designed specifically for use in electronic and industrial control equipment where severe mechanical shock is encountered, ring type rheostats have applications in generator or motor field control, filament and battery circuit control, and in connection with rectifiers and voltage regulators. Base, core and collector ring support assemblies are of high dielectric strength, glass-bonded mica. Toroidally core wound resistance wire is secured with a silicone compound, separating turns and protecting the wire. Balanced twin contact shoe construction eliminates backlash and assures smooth, positive control. Ratings are 50 w continuous duty.

tolerance of +20 to −10 per cent, maximum resistance value 20,000 ohm. **Ward Leonard Electric Co.**, Mt. Vernon, N. Y.

Circle No. **74** *on Reply Card*



No. 75—

Vacuum Pump Assembly

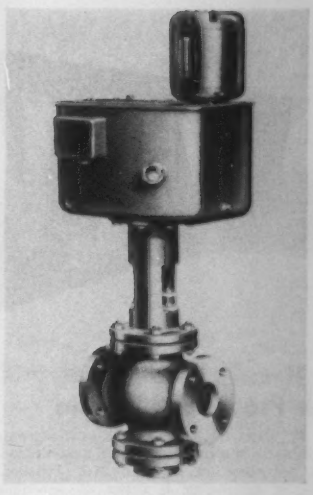
Combination pressure and vacuum pump is oil-free, positive displacement rotary vane type. Pressure pump located at back of motor has 400 cu inches per minute capacity at 30 psi gage discharge pressure, at 60 cycles per second, continuous duty. Capacity is reduced approximately 16.6 per cent at 50 cycles per second motor operation. Blades are self-lubricating, carbon-graphite composition. Pump features positive starting and pumping in temperature range of −55 to 55C. Vacuum pump, mounted on front of motor, may be operated simultaneously with pressure pump or separately. Vacuum pump will operate normally at −30F and will operate to low temperature of −55C with reduced capacity. **Lear-Romec Div., Lear Inc.**, Elyria, O.

Circle No. **75** *on Reply Card*

No. 76—

Valve Actuator

Advantages and utility of electronic control systems are increased through use of self-contained electrohydraulic valve actuator. Actuator permits electrical output to be applied directly to final control element in these electronic control systems. Actuator is a complete self-contained unit including control valve, hydraulic power source and proportional positioning mechanism which can be used with existing electronic controllers. Outside connections consist of signal wires from controller and an electric power supply. Signal current is applied to high-resistance coil—3000 ohm or more—which moves in magnetic field. Linked to the coil is jet pipe which converts an electrical signal of less than 50 milliwatts into the powerful stroke of a control valve. Valves move at speed of better than 1 ips. Thrusts of 600 lb and higher can be handled, with strokes presently available up to 2 inches. **Askania Regulator Co.**, 240 E. Ontario St., Chicago 11, Ill.



Circle No. **76** *on Reply Card*

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from .018" to .065" thick...
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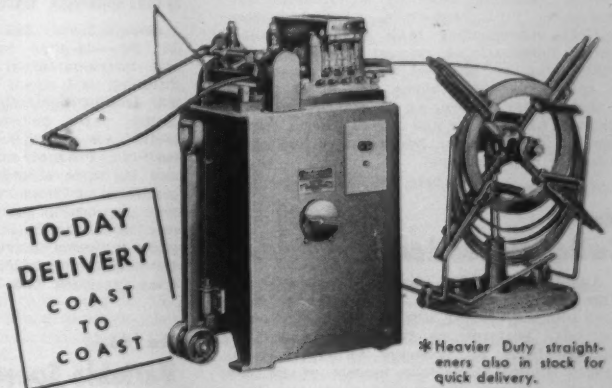

*Heavier Duty straighteners also in stock for quick delivery.

Littell "308" Variable Speed Straighteners flatten coil stock...synchronize feeding of stock with speeds of automatic presses . . . simplify hand feeding. The "308" has brought new speed, efficiency and economy into stamping, blanking and shearing operations from coast to coast. Get full details on these portable straighteners.

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REELS • AIR BLAST VALVES
District Offices: Detroit, Cleveland

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new CATALOGS AND LITERATURE

No. 77—

High Production Presses

E. W. Bliss Co., Canton, O.—28-*page catalog*—Complete line of high speed automatic presses is described in Catalog 27C. Problems inherent in operating a press at speeds of up to 800 strokes per minute are covered, with solutions to these problems indicated. Components of presses including air friction brake and clutch, variable speed drives, automatic lubricating system and top stop control are illustrated. Presses which are designed to meet special requirements are also illustrated, and photographs and specifications of numerous models are included.

Circle No. 77 on Reply Card

No. 78—

Heavy Duty Air Cylinders

Petch Mfg. Co., 463 York, Detroit 2, Mich.—12-*page bulletin*—Applicable to automation, die work, conveyor applications, foundry, press and welding equipment, machine tools and fixtures, heavy duty air cylinders are discussed in illustrated bulletin. Engineering drawings and specifications are included for five interchangeable mountings.

Circle No. 78 on Reply Card

No. 79—

Quick Opening Doors

Struthers Wells Corp., Titusville, Pa.—8-*page bulletin*—Large continuous pressure curing oven is made completely automatic through use of quick opening doors discussed in bulletin. Doors have a variety of industrial applications, including those on a horizontal impregnating tank, autoclave, vertical retorts, vertical impregnating tank which are illustrated. Pneumatic or manual locking and unlocking can be provided by either expansion or contraction of a shear ring in or out of a shell flange groove, or by rotation of locking ring having lugs and wedges which engage lugs on door flange. Doors are furnished to customer specifications.

Circle No. 79 on Reply Card

No. 80—

Switch Mechanisms

Automatic Electric Sales Corp., 1033 W. Van Buren St., Chicago 7, Ill.—32-*page handbook*—Series of five articles discusses control methods, performance ranges and operating characteristics of Strowger switches. Photographs illustrate various models of switches in line. Separate discussions cover two types of rotary switches and precious metal contacting for industrial stepping switch applications. Specifications, capacitance ratings and general information on switches are included.

Circle No. 80 on Reply Card

No. 81—

Gear Grinding Machines

Gear Grinding Machine Co., 3901 Christopher, Detroit 11, Mich.—8-*page bulletin*—New automatic features of gear grinders including automatic down feed, trimming, loading, rejection and release are illustrated in bulletin. Different types of grinders such as gear and spline, helical gear and large internal and external gear grinders are illustrated and their specifications given. Also covered are rack grinders, crowned gear tooth grinders, face spline grinding machines and oscillating grinders.

Circle No. 81 on Reply Card

No. 82—

Bellows and Metal Hose

Flexonics Corp., 1438 S. Third Ave., Maywood, Ill.—16-*page booklet*—Written to assist engineers in the selection of proper bellows or metal hose for his particular application, booklet #150 includes photographs and specifications of numerous models. Typical bellows applications, as in valve stem seals, steam traps, rotary shaft seals and oven and dryer controls are illustrated. Applications of various types of metal hose are also covered, with photographs included.

Circle No. 82 on Reply Card

No. 83—

Compression Spring

Flex'ator Div., Hunter Spring Co., Lansdale, Pa.—16-*page booklet*—Characteristics and properties of constant-force compression spring which exerts same force at any deflection are covered in booklet. Materials, types of ends, methods of mounting, design formulas and design standards are also included. Four tabular form design charts each representing a different fatigue life requirement, or stress level, are offered as specification instructions.

Circle No. 83 on Reply Card

No. 84—

Instrument and Control Systems

Hagan Corp., 323 Fourth Ave., Pittsburgh 30, Pa.—28-*page catalog*—Automatic control and instrumentation components; water conditioning and steam testing equipment; chemical feeding devices; chemicals for food processing, paper processing and for metal protection are among subjects covered in Bulletin GSP-901. Products and services of Hagan Corp. and its three subsidiaries are discussed. Photographs of force measuring devices, motor load regulators, conductivity meters and various other equipment are included. The company engineers instrument and control systems for combustion applications as well as industrial processes and specialized applications.

Circle No. 84 on Reply Card

No. 85—

Variable Speed Drives

Sterling Electric Motors Inc., 5401 Telegraph Rd., Los Angeles 22, Calif.—8-*page bulletin*—Information on factors in drive selection and description of types of automatic and remote speed control accessories available are included in bulletin. Pneumatic control device which will change output speed of variable speed transmission in direct proportion to any change in input signal is used in production process where sensing device can interpret variations such as pressure, temperature, time, speed, position, color, liquid level, shape, viscosity, sound, radiation and proportioning. Preset control which is used wherever remote and rapid selection of one or a sequence of predetermined speeds can facilitate operations is shown. Numerous photographs and sketches illustrate the bulletin.

Circle No. 85 on Reply Card

No. 86—

Time and Energy Analyzer

Stewart Instrument Co., 6507 Grand River Ave., Detroit 8, Mich.—20-*page booklet*—Instrument designed to determine operating efficiency of electric motor driven machines by measuring productive time and energy involved is discussed and illustrated in booklet. Component parts of analyzer are instrument and transformer units and interconnecting cable. Booklet includes data on operating sensitivity, suggested test data sheets and specifications of analyzer. With newly offered instrument it is possible to find comparative values in selecting speeds, feeds, tools, machinability and time standards.

Circle No. 86 on Reply Card

No. 87—

Automatic Marking Tools

Geo. T. Schmidt Inc., 4100 Ravenswood Ave., Chicago 13, Ill.—16-*page booklet*—Range of marking equipment from hand stamps to automatic marking machines is discussed in #11 brochure. Photographs and brief description of 19 marking machinery models are given, with illustrations of machinery in different applications also included. Marking tools and their applications are also covered.

Circle No. 87 on Reply Card

No. 88—

Liquid Level Transmitter

Foxboro Co., Foxboro, Mass.—8-*page bulletin*—Closed tank liquid level measurement and control with cell liquid level transmitter is subject of illustrated bulletin. The cell transmitter measures height of liquid in closed vessels under pressure. Diagrams illustrate principles of operation and suggested installation layout. Complete specifications and dimensions of transmitter are included, as well as illustrations of other liquid level components such as indicators, recorders and control valves.

Circle No. 88 on Reply Card

No. 89—

Rotocycle Meters

Rockwell Mfg. Co., Meter & Valve Div., 400 N. Lexington Ave., Pittsburgh 8, Pa.—8-*page bulletin*—New line of all-bronze meters which are recommended for metering alcohols, brine, water, ketones, organic esters, some mild acids, beverages, sugar solutions and syrups is discussed in bulletin. Photographs illustrate meters used in conjunction with valves to shut off flow automatically at a predetermined volume. Meters also are used for remote registration in controlling overall metering operations from a central point.

Circle No. 89 on Reply Card

No. 90—

Lubricating By Metallic Solids

Imperial Oil & Grease Co. Inc., 6399 Wilshire Blvd., Los Angeles 48, Calif.—8-*page bulletin*—Self-lubricating metallic solids which actually plate metal surfaces, thus reducing friction on bearing surface areas, are covered in illustrated bulletin. Alloy oils are blended in all recognized SAE viscosities; alloy gear oils meet wide requirement of gear applications including those of hypoid, helical, herringbone, spur and worm types. Grease, which is available in four weights, makes it possible to use

HERE IS THE LATEST IN AUTOMATION "HOW TO"

less grease, greasing less often, with safer lubrication. Outside gear grease and spindle oils are also described.

Circle No. 90 on Reply Card

No. 91—

Gravity Conveyors

Metzgar Conveyor Co., Grand Rapids 4, Mich.—38-page catalog — Wheel and roller, live roller, power belt, floor-to-floor, press helpers, midget roller, midget wheel and nylon roll conveyors are among types covered in illustrated catalog. Discussion on application of conveyors, their construction features, and power controls is included. Accessories such as stands, bases, switches and spurs for materials handling line are illustrated and described.

Circle No. 91 on Reply Card

No. 92—

Magnetic Pulley

Stearns Magnetic Inc., Milwaukee 46, Wis.—16-page booklet—Detailed specifications on magnetic pulleys and pulley separators and simplified selection method which assists user to accurately select right size pulley for his application are among information in illustrated booklet. New two-coil pulley design creates a magnetic field of increased strength and more effective shape, enabling use of smaller diameter pulleys than previously possible. Installation photographs show pulleys being used in a foundry, a lead zinc mill, a coal mine and copper mine. Booklet also contains tables of weights for minerals, ores, chemicals, metals, grains, seeds, wood, etc.

Circle No. 92 on Reply Card

No. 93—

Data Processing Systems

Logistics Research Inc., 141 S. Pacific Ave., Redondo Beach, Calif.—8-page bulletin—Detailed description of the ALWAC III data processing system which consists of an electronic digital computer, a punched card converter, magnetic tape storage, automatic typewriter and punched paper tape is given in illustrated bulletin. Data on magnetic drum memory, speed of operation, programming, input-output, controls and indicators, physical characteristics and reliability are included.

Circle No. 93 on Reply Card

No. 94—

Package Drives

Allis-Chalmers Mfg. Co., 1205 S. 70th St., Milwaukee, Wis.—8-page bulletin—Speed control of machine tools and other applications requiring accurately variable speed over wide range are provided by package drives discussed in illustrated bulletin. Package drive consists of power unit, operator's control station and drive motor—all designed to operate as a unit. Available in five cabinet sizes with drive motor range of 5 to 150 hp, drives feature magnetic amplifier generator field control, preset control for repetitive operations, control of all machine functions from one or more remote points and full protection against overload and undervoltage. Photographs illustrate drives which are used in machine tool, textile, metal, paper and other industries.

Circle No. 94 on Reply Card

No. 95—

Damping Devices

Gabriel Co., Dept. 2B, 1148 Euclid Ave., Cleveland 15, O.—22-page booklet—Control of linear motion in automotive and industrial applications is effectively accomplished by damping devices. Units can limit velocity, arrest motion, cushion application of force, damp vibration of suspended mass or control movement resulting from rotary motion. Six standard damping devices are described and illustrated in detailed drawings and charts.

Circle No. 95 on Reply Card

No. 96—

Packaging Machinery

Weigh Right Automatic Scale Co., Joliet, Ill.—12-page bulletin — Gross weight fillers, volumetric equipment, coupon inserters, auger packers, carton sealers, net weighers, conveyors, elevators and automatic machinery for controlled packaging are discussed. Photographs of various equipment illustrate actual applications. Capacity, output and products handled by different models are given.

Circle No. 96 on Reply Card

No. 97—

Germanium Transistors

Raytheon Mfg. Co., 55 Chapel St., Newton 58, Mass.—11-page bulletin—Four transistors which are smaller in size than former units are covered in technical bulletin. First three types are designed for use in audio or low radio frequency applications; fourth is low noise transistor for use in low level audio circuits. Characteristics, electrical data, mechanical data and application information are included.

Circle No. 97 on Reply Card

No. 98—

Solenoid Operated Valves

Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.—12-page bulletin—Cataloged according to service condition—air, oil or water, solenoid operated four-way, three-way and shut-off valves are the subject of three illustrated pamphlets. Air valves with pressure ratings of 0 to 250, 1000 and 1500 psi are discussed in 58-A; 58-H discusses oil valves rated at 0 to 250, 1500 and 3000 psi; and 58-W covers water valves rated at 0 to 250, 1500 and 3000 psi. Valve characteristics, flow patterns, overall dimensions, photographs and ordering data are included.

Circle No. 98 on Reply Card

No. 99—

Industrial Enclosed Switches

Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.—28-page catalog —Written as an aid to plant engineering and maintenance man, Catalog 83 describes in detail variety of enclosed switches designed for use on either ac or dc industrial applications. Included are general purpose switches, sealed switches, heavy duty limit switches, hand operated switches and maintained contact switches. All models are available in a variety of actuator designs, contact arrangements and electrical ratings. Photographs, dimensional drawings, circuit diagrams, electrical data and technical information are included.

Circle No. 99 on Reply Card

No. 100—

Buffing and Polishing Compound

Hanson-Van Winkle-Munning Co., Matawan, N. J.—24-page catalog—Characteristics and uses of over 100 buffing and polishing compounds are described and illustrated in Bulletin Co-103. Illustrated automatic equipment for application of buffing compound includes application gun, electric timer unit and pump assembly. Sketch demonstrates application equipment in a multiple head installation. Specific compounds are classified and described, with recommended usage, under general headings of Tripoli, cut and color compounds, steel and stainless steel buffing compounds, emery paste and cake, crocus, polishing lubricant, rouges, greaseless compounds and special polishing and buffing compounds.

Circle No. 100 on Reply Card

No. 101—

Electric Motors

Howell Electric Motors Co., Howell, Mich.—16-page booklet — Cut-away illustrations and diagrams show advances in design which have been built into new rerated electric motors. New series are smaller, lighter and cooler running, and feature new motor cooling system utilizing a slotted stator design. Fully protected bearing construction using a greasing system to check over-lubrication, lighter weight and strength of motors are among features emphasized in Bulletin N-100-R.

Circle No. 101 on Reply Card

No. 102—

Cylindrical Grinding Machines

Landis Tool Co., Waynesboro, Pa.—20-page booklet—Photographs and descriptions of integrated production lines, automatic grinders and standard machines are included in booklet. Actual lines which are grinding bearing races and valves automatically are shown, with production steps indicated. Multiple wheel hydraulic grinding machine, semiautomatic hydraulic cam grinder, concentric grinder with feedback and cylindrical grinders are illustrated.

Circle No. 102 on Reply Card

No. 103—

Pneumatic Control Systems

Westinghouse Air Brake Co., Industrial Products Div., Wilmerding, Pa.—12-page bulletin—Valves, cylinders, actuators, relays, and positioners for pneumatic control systems are discussed and diagrammed in bulletin D0-00-1. Applications of system in reel windup machine of hot wire drawing mill, in piercing press, in carboning machine and in clutch control are illustrated, with the problem and solution indicated. Air service accessories and components are illustrated and described.

Circle No. 103 on Reply Card

No. 104—

Pressure Transducers

Statham Laboratories Inc., 12401 W. Olympic Blvd., Los Angeles 64, Calif.—12-page bulletin—Various models of pressure transducers are discussed and illustrated in bulletin. One model is designed for measurement of absolute pressure; a second type measures differential pressure; a third type measures gage pressure. Pressure adapters for use where application requires uses of chamber-type

NEW CATALOGS AND LITERATURE

pressure transducer are also covered. Photographs, sketches and operating characteristics of transducers are included.

Circle No. 104 on Reply Card

No. 105—

Conveyor Applications

Standard Conveyor Co., North St. Paul, Minn.—16-*page booklet*—Photographs illustrate production applications of gravity and power conveyors in munitions plants, aluminum, brass and steel mills, airplane plants, machine shops, electrical appliance manufacturing plants and foundries. Pneuamtic tube systems for handling messages and miscellaneous items are also mentioned.

Circle No. 105 on Reply Card

No. 106—

Magnetic Tape Recorders

Cook Research Laboratories Div., Cook Electric Co., 2700 N. Southport Terminal, Chicago 14, Ill.—16-*page booklet* — Photographs and specifications of magnetic tape recording mechanisms which are designed to meet severe environmental conditions and rigid size and weight limitations are included in illustrated booklet. Drive mechanisms are used for various recording and playback applications in collecting data aboard aircraft and missile vehicles under test. Several magnetic tape recording systems and a magnetic tape playback system are illustrated and discussed.

Circle No. 106 on Reply Card

No. 107—

Electropneumatic Control

Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.—8-*page bulletin*—Discussion covers electropneumatic current-adjusting type control system for use in processes in oil and chemical industries which normally require a pneumatic control system, but for which an electrical control system would offer advantages. Control unit consists of a primary element, a recording or indicating instrument, a control unit, an electropneumatic converter, and any conventional pneumatically operated valve or valve positioner. Photographs and line drawings illustrate complete control system and its components. Description of how control unit provides automatic reset and rate actions is also given.

Circle No. 107 on Reply Card

No. 108—

Process Pumps

Ingersoll-Rand Co., 11 Broadway, New York 4, N. Y.—20-*page booklet*—Vertically split, single and two-stage process pumps are described and illustrated in booklet, Form 7094-B. Range of discharge diameters of pumps which are built to API specifications is from 1 to 8 inches including capacities to 3200 gpm, heads to 925 ft, at temperatures to 800F. Design features, dimension tables, cross sectional diagrams and installation photographs are included.

Circle No. 108 on Reply Card

No. 109—

Fluid Drive

American Blower Corp., Detroit 32, Mich.—8-*page bulletin*—Type VS Class 2F Gyrol fluid drive for diesel engine applications is discussed in illustrated bulletin. Construction and operation features of adjustable speed fluid drive as applied to diesel engine installations are covered. Operating characteristics for oil field machinery applications such as draw works, rotary and slush pumps are described in detail. Use of units in compounding multiple engine drives is also discussed. Installation photographs are used to illustrate Bulletin No. 9619.

Circle No. 109 on Reply Card

LITERATURE BRIEFS

No. 110—

Transducer Component

Decker Aviation Corp., 1361 Frankford Ave., Philadelphia 25, Pa.—2-*page pamphlet*—Unit for analog conversion of changes in capacitance to changes in voltage is discussed and illustrated. Unit may be applied to measurement of any physical phenomena which can be resolved into changes of capacitance, including micrometric and macrometric displacement, angular motion, vibration, temperature, pressure, liquid level, humidity, dielectrica, continuous weighing, etc. Containing an ionization transducer and necessary excitation source, unit requires only a capacitor configuration and power supply to provide an analagous output signal.

Circle No. 110 on Reply Card

No. 111—

Remote Control Systems

Taller & Cooper Inc., 75 Front St., Brooklyn 1, N. Y.—6-*page pamphlet*—Case history of remote control system used to operate automatically a deep well water supply system is included in pamphlet. Control system is also used for chemical and material supply systems in industry, as well as water supply. Chart illustrates system operation; application photographs are also included for the equipment which is capable of controlling from 10 to 16 separate functions.

Circle No. 111 on Reply Card

No. 112—

Gear Lubricants

Alpha Molykote Corp., 65 Harvard Ave., Stamford, Conn.—2-*page pamphlet*—Test data describe open gear lubricant and lithium base lubricant in terms of frictional torque versus jaw load. Specifications and prices of lubricants which are recommended for use on construction machinery, mechanical presses, power shears, etc., are included in Bulletin 105.

Circle No. 112 on Reply Card

No. 113—

Gluer and Wrapper

High Production Machine Co. Inc., 2675 University Ave., St. Paul 14, Minn.—2-*page pamphlet*—Photographs illustrate adjustments which can be made to positioning assembly and cross feed carriage of semiautomatic wrapping and gluing machine. Description of machine which will produce up to 2000 tight-wrapped stayed boxes per hour is included in pamphlet.

Circle No. 113 on Reply Card

No. 114—

Materials Handling Study

Towmotor Corp., 1226 E. 152nd St., Cleveland 10, O.—4-*page pamphlet*—Information on method used to reduce materials handling costs and increase plant storage capacity is given in illustrated case study. Photographs indicate how fork lift trucks were used to expedite receiving, processing, storage and shipping operations.

Circle No. 114 on Reply Card

No. 115—

Temperature Conversion Table

Thermo Electric Co. Inc., Rochelle Park P.O., Saddle Brook, N. J.—2-*page pamphlet*—Loose-leaf type chart converts degrees Fahrenheit to Centigrade or vice versa from —400 to 4000 degrees and gives temperature ranges of various sensing elements. Thermocouples, resistance bulbs and radiation heads are also illustrated.

Circle No. 115 on Reply Card

No. 116—

Weight Printer and Totalizer

Weighing Components Inc., 64 Fulmor Ave., Hatboro, Pa.—2-*page pamphlet*—Photograph illustrates automatic scale which uses flexural platform with strain-gage load cell weight transmitter and integrally mounted belt conveyor. Printer console contains adding machine printer-totalizer-item counter and amplifier, servosystem, and analog-digital converter required to convert electrical input signal from load cell to actuate the printer. Unit is useful in checking and weighing of bags, drums and cartons. Schematic drawings illustrate applications, capacities and dimensions of printer and totalizer.

Circle No. 116 on Reply Card

No. 117—

Reference Voltage Source

Avien Inc., 58-15 Northern Blvd., Woodside 77, N. Y.—2-*page pamphlet*—Design and performance data of tubeless dc reference voltage source for measurement and control circuits are given in illustrated pamphlet. Block schematic drawings show typical application of unit for control systems, measurement circuits and stabilizing circuits.

Circle No. 117 on Reply Card

No. 118—

Colloidal Dispersions

Acheson Colloids Co., Div., Acheson Industries Inc., Port Huron, Mich.—4-*page pamphlet*—Revised material on 42 colloidal and semi-colloidal dispersions for operational functions, maintenance, lubrication, machine design and industrial applications includes information on new mica-and-water product for use as metalworking lubricant. Applications, carriers and diluents for each product are given.

Circle No. 118 on Reply Card

No. 119—

Permanent Magnetic Drum

Homer Mfg. Co. Inc., Dept. 286, Lima, O.—6-*page pamphlet*—Applications and features of permanent magnetic drums which automatically and economically remove tramp iron or ferrous materials from gravity or conveyor transported products are covered in pamphlet. Diagrams, performance data, pictures and descriptions of various models are included.

Circle No. 119 on Reply Card

No. 120—

Selenium Rectifiers

Sarkes Tarzian Inc., Rectifier Div., 415 N. College Ave., Bloomington, Ind. — 4-*page pamphlet*—Development of artificial barrier layer and counter electrode which permit operation of selenium rectifiers at temperatures up to 150C is covered in illustrated pamphlet. Charts show cell ratings, aging characteristics, and operating characteristics of single phase and three phase rectifiers.

Circle No. 120 on Reply Card

No. 121—

Printed Wiring Boards

General Electric Co., Electronic Components Dept., W. Genesee St., Auburn, N. Y.—6-*page pamphlet*—Technical data and circuit design pointers for GE "Thru-Con" printed wiring boards are given in illustrated pamphlet. Layout and design information, specifications on base and conductor materials, use characteristics and other customer information such as art work suggestions, etc. are included. Boards are made by an additive process which plates copper through component lead holes, eliminating need for eyelets, reducing total parts requirements and providing for application of circuits to both sides of boards.

Circle No. 121 on Reply Card

Further Information?

It's YOURS for the asking

NEW EQUIPMENT . . . COMPONENTS . . . LITERATURE

(STARTS PAGE 79) (STARTS PAGE 98) (STARTS PAGE 112)

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71	72	73	74	75	76	77	78	79	80	81	82	83	84
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AUTOMATION abstracts

AUTOMATION . . . KEY TO AIR FORCE LOGISTICS

By GEN. E. W. RAWLINGS
Air Materiel Command
United States Air Force

BY SIMPLEST definition automation is the substitution of machine energy for human energy, mental or physical. It is a concept as old as the water wheel, literally electrified and fused into a powerful new expression by advances in science and technology during and since World War II. The first industrial revolution, triggered by the development of steam power, resulted in men running machines for faster, cheaper mass production. Automation ushers in an era of machines running machines, toward the goal of completely automatic industrial operation.

In its full development automation has, of course, awesome possibilities for the betterment or disruption of our economic system. In industry both management and labor are studying it warily, but with increasing confidence that it can be constructively channeled for the common good. Our Air Force logistics mission is so closely linked to the nation's production potential, and our need for speed and economy is so great, that we also have a major stake in automation. It has great promise for us in three particular areas of logistical concern.

Great Expectations

First—and of primary importance to our Air Force mission—automation can greatly increase our operational effectiveness. Logistics is the muscle of striking power, as strategy is the brain. The effective application of air power on a global scale poses innumerable problems of support. The high cost and rapid rate of obsolescence of modern air materiel forbid, in the long alert ahead of us, the practice of worldwide stockpiling which carried us through the last war. For stockpiling we must substitute a flexible mobility that will allow us to focus quickly an effective stream of our limited materiel support upon any given area of operations.

Airlift alone cannot accomplish this. Proportionately it affects too small a segment of the whole support cycle. But if automation can substantially reduce the time required to send a requisition, process it, and get it on its way, then we shall have quickened the whole pulse of support. This speed-up of the reaction time between *need* and *have* is the essence of logistical effectiveness. We have already seen on a limited scale the proof that this can be done, that automation can reduce to hours processes that have formerly required months for completion. It is not unusual for about 80 per cent of our present support cycle to be consumed not in transport but in transmitting and processing paperwork and processing the materiel itself.

Moreover automation can do much to ensure our continued effectiveness when effectiveness is most crucial, at the moment of meeting the stresses of any future all-out mobilization. Manpower will always be one of our critical shortages in an emergency mobilization, our Achilles heel in any contest with the massed millions of the Communist complex. Even the maintenance of technological superiority—more men on more or on better machines—can pose a tight squeeze, as we discovered in World War II when we struggled continually to maintain the vital balance between the manpower allotted to the armed forces and that essential to defense production. In the rapid build-up after the Communist aggression in Korea, we at Air Materiel Command found manpower our greatest bottleneck. Even in that limited war, which drew upon only a comparatively small part of our national manpower pool, the time-lag of training and adapting the human work force was a major contributing factor to our sluggishness in mobilizing. In any future all-out mobilization we shall have no such margin to gather our forces.

By trimming the manpower variable to a minimum, automation can give us increased stability, a more reliable and accurately predictable expansion factor. It will allow us to concentrate available qualified manpower at the key directive points, throughout the Air Force logistical system and in industry. Machines, with minimum human intervention, can, if necessary, work 24 hours a day to give us the essential emergency output. In short they can constitute a tremendous stand-by force, a canned power pool far beyond any which the national economy could conceivably support in terms of manpower.

The second great promise of automation to our Air Force logistical mission is economy. If we are to sustain a ready striking force for the indefinite duration of the cold war, maximum econo-

my is imperative. We must pare the cost of long-term airpower to a soundly supportable percentage of the national resources. Otherwise as a nation we shall make ourselves "insurance poor", sapping the very economic vitality which is essential to our continued freedom.

The saving in total manpower, an expensive and always strictly limited commodity in our operations, is self-evident. Since the beginning of the Air Force build-up we have provided for steadily expanding logistical responsibilities under fixed manpower ceilings. In fact Air Materiel Command's work force has been reduced within the last few years. If the multitude of purely repetitive tasks of the logistical system can be taken over largely by machines, we shall be able to use the manpower available to us at higher levels of skill, with a far better return for our investment in terms of per capita production. Substantially improved logistical production has become a necessity if we are to support more air power with proportionately fewer people.

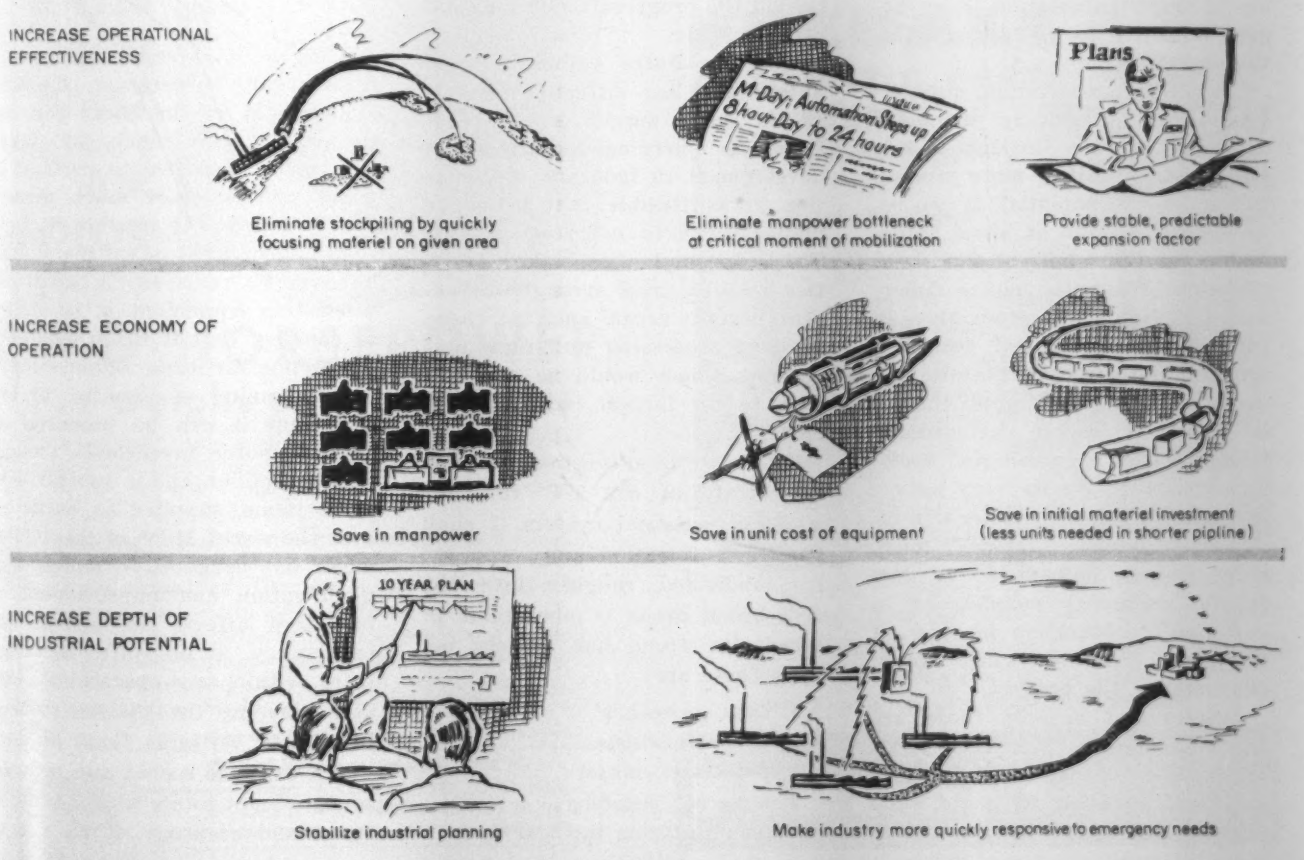
We can also anticipate that the greatly increased volume of industrial production made possible by a similar optimum use of available industrial manpower will eventually reduce the unit cost of our equipment. Though the adjustments of the transition period may delay the full effect of this natural law of economics, it is an eventual certainty.

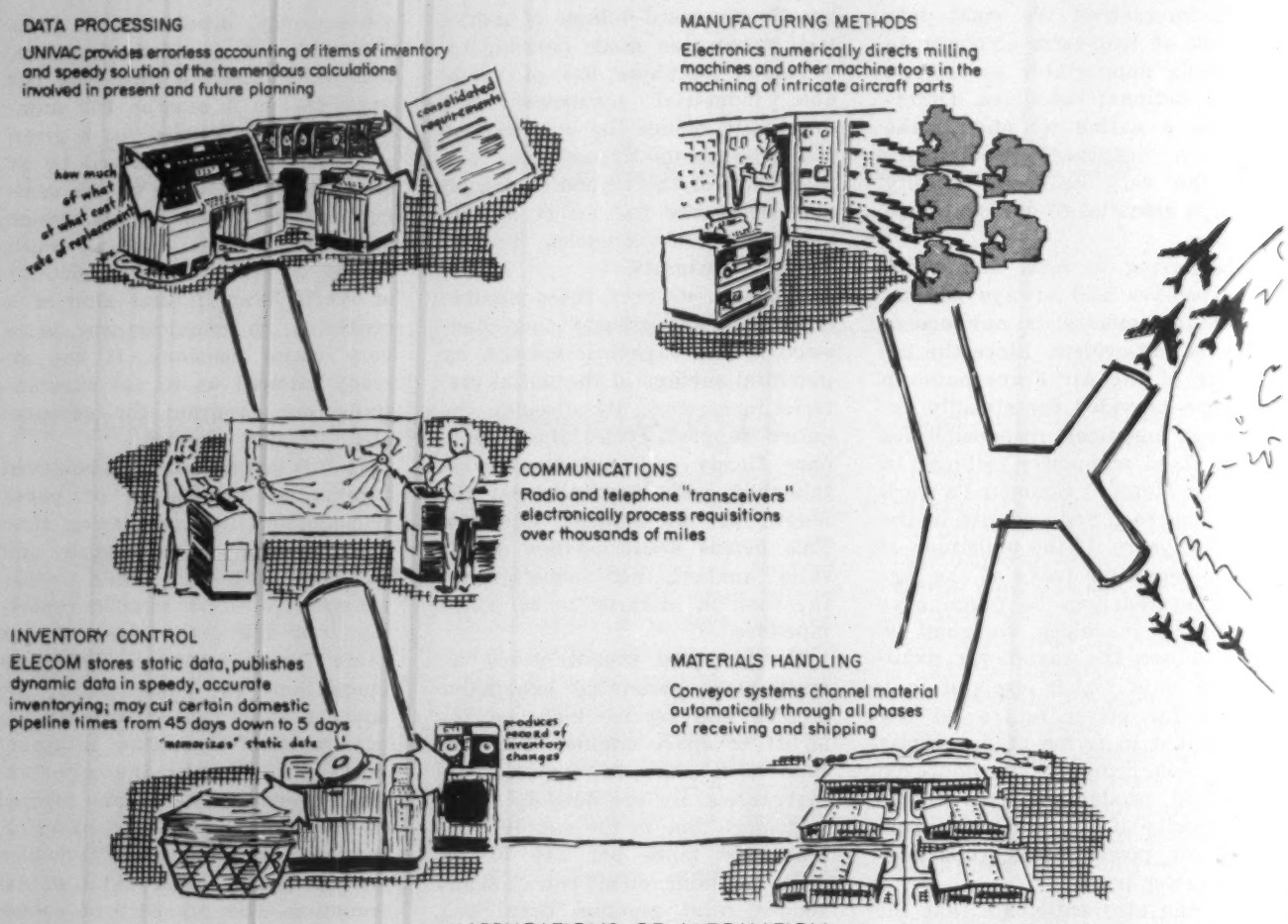
Actually, however, these possible economies are greatly over-shadowed in our logistical mission by potential savings in the initial materiel investment. By speeding the entire support cycle, automation, once firmly and consistently established, will drastically cut the length of our support pipelines. This means great savings in the total amount, and consequently the cost, of materiel to fill those pipelines.

For the past several years, we have been conducting exhaustive studies and service tests on the airlift of spare engines, a prime, high-value item in our materiel inventories. By speeding up actual transport time in the supply cycle from 150 miles per day to 150 miles per hour, airlift can radically reduce total pipeline time, and, consequently, investment in pipeline stocks. We found, for instance, that when pipeline time was cut from 4½ to 3 months the number of engines needed for a given operation could be reduced by at least one third. When we are dealing with jet power plants, which in some instances cost as much as did an entire fighter aircraft of World War II, that kind of a reduction in requirements is a very major economy. It has already allowed us to cut substantially our program for procurement of new engines.

In this instance we also achieved substantial elimination of paper transmission and processing time by a system of forecasting and automatic shipment, made precise by means of serial number reporting. For the great mass of our other items, however, airlift includes only the small arc of the support cycle that represents actual materiel flow, time in transport. If we consider the opportunity for pipeline reductions offered in the much larger area of information flow—the area to which we can apply the stimulus of automation—the prospect of econo-

THE POTENTIAL OF AUTOMATION


INCREASE OPERATIONAL EFFECTIVENESS
Eliminate stockpiling by quickly focusing materiel on given area
M-Day: Automation Steps up 8 hour Day to 24 hours
Eliminate manpower bottleneck at critical moment of mobilization
Plans
Provide stable, predictable expansion factor
INCREASE ECONOMY OF OPERATION
Save in manpower
Save in unit cost of equipment
Save in initial materiel investment (less units needed in shorter pipline)
INCREASE DEPTH OF INDUSTRIAL POTENTIAL
10 YEAR PLAN
Stabilize industrial planning
Make industry more quickly responsive to emergency needs


DATA PROCESSING
UNIVAC provides errorless accounting of items of inventory and speedy solution of the tremendous calculations involved in present and future planning
how much
of what
at what cost
rate of replacement
consolidated requirements
MANUFACTURING METHODS
Electronics numerically directs milling machines and other machine tools in the machining of intricate aircraft parts
COMMUNICATIONS
Radio and telephone "transceivers" electronically process requisitions over thousands of miles
INVENTORY CONTROL
ELECOM stores static data, publishes dynamic data in speedy, accurate inventorying; may cut certain domestic pipeline times from 45 days down to 5 days
"memorizes" static data
produces record of inventory changes
MATERIALS HANDLING
Conveyor systems channel material automatically through all phases of receiving and shipping

APPLICATIONS OF AUTOMATION

my through automation is an urgent incentive to its full exploitation.

As a third expectation, automation offers a greatly increased depth of defense through a stabilized and infinitely more productive industrial potential. It can be, in essence, a kind of blood transfusion for the whole of industrial planning. Whatever makes American industry more productive, in turn gives our armed forces a broader and stronger backing, always provided, of course, that it is achieved within a national framework of economic and sociological health. By its very nature automation can also make our industrial defense arsenal much more quickly responsive to any future emergency mobilization, a cardinal consideration in view of the swift deadlines which would characterize the conflict.

Briefly and broadly those are the reasons why we consider the automation element of the new logistical equation to be of such importance. They are the thrust behind the progress which we have already made.

Our Air Force emphasis upon automation has differed, naturally, in some significant respects from the emerging pattern of its development in industry. Automation is so flexible that it means many things to many operations. The scope and mass of our logistics mission tend strongly to accent certain areas, such as those of data processing and communications, which would be germane only to the largest industrial operations.

Therefore in surveying the present "state of the art" throughout our logistical system, I shall define automation as we see it, subdivided roughly into the five broad areas of operations in which the trend has already begun. These are:

1. Data processing
2. Communications
3. Inventory control
4. Materials handling
5. Manufacturing methods

Data Processing

Accurate and rapid data processing is the cornerstone of sound logistics. It is the basis for determining how much of what equipment is needed to perform a given mission; how much money will be required to procure it; how soon and in what quantities it will have to be replaced. In addition, when this equipment is so bulky or complex that it taxes available production facilities, advance long-term planning is essential to ensure that it can be procured at all. Air Force inventories include about a million and a quarter separate items, supplied to bases all over the world. Much of this equipment is constantly undergoing modification and improvement, a fact that affects its normal life expectancy, as do shifts in usage rates within any operational theater. Keeping the shelves stocked involves a veritable flood of data which must be sorted and reduced to significant totals with maximum speed and accuracy, if we are to

have the right amount of the right equipment at the right time and place, without waste and without the delay which could mean disaster.

Electronic data processing equipment gives every promise of yielding the solution. We now have installed at Headquarters, Air Materiel Command, Remington Rand's room-size electronic system known as UNIVAC. It follows taped instructions, adds, multiplies, divides, sorts, remembers, and reports results with lightning speed. It can perform long sequences of operations without human intervention, accomplish in minutes work which would require weeks of human computations. It is self-checking—the moment its dual, simultaneous processings do not agree, the system stops and waits for the indigestible error to be removed.

We are just beginning to exploit the infinite possibilities of UNIVAC. Typical complexes of data processing now being explored for application are logistics budget computations, including a major portion of the fiscal year 1957 logistics financial plan, analysis of technical failure, engine management, air logistics transport schedules, flying hours and aircraft inventory factors, government furnished aircraft equipment allocations, and several problems associated with industrial planning.

UNIVAC is proving itself a fundamental management tool in its adaptability to a variety of problems which seems to be limited only by our facility in isolating and expressing them to the machine. It is already improving our ability to reflect rapid changes in Air Force programs and inventory balances and to plan more accurately for future support. It is, in a sense, the axis of our beginning in automation and is consistently useful in helping us to evaluate other applications for electronic devices within the system.

We are now concluding plans to use IBM Type 650 electronic data processing machines in our Air Materiel areas, depots, and logistical control groups, the filter points for overseas supply. We estimate that in key spots the electronic systems will give us an emergency potential for expanding operations to four times the present volume, with only a very small increase in personnel and other equipment.

The data processing equipment in use at this time or projected for the immediate future is actually only a threshold approach to what will be available before long. Remington Rand, for instance, has recently announced UNIVAC II, a giant computer with double the speed and capacity of the present model. A similar ratio of improvements is expected in International Business Machine's 705 computer, a successor to the current 702. These developments are fairly good indications of one characteristic feature of automation which augurs well for progress. You don't have to push it; it pushes you. The main problem at this point is to set a course that will make the most of its built-in momentum.

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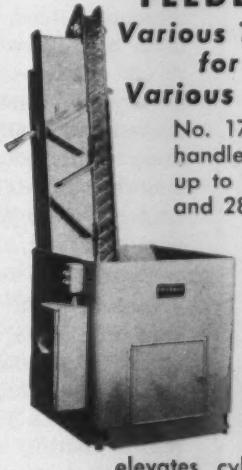

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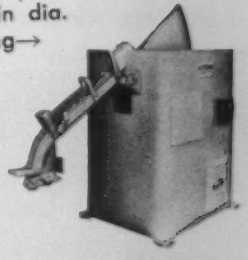

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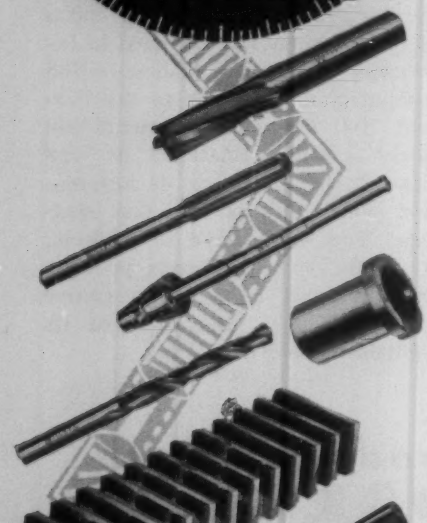

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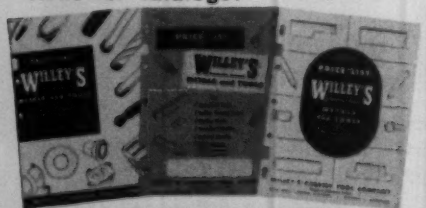

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Communications

In the field of communications, automation is by no means new. The automatic dial telephone and the wire photo service are two of a number of long-established examples. Communications offer a natural area for further extension of the principles of automation. Little can be accomplished in speed of supply or pipeline reduction by airlifting equipment which must originally be requisitioned by methods tied down to surface transport. On the other hand faster oral methods of requisition, practical only in an emergency, are particularly vulnerable to human error.

In March of 1955 we established the first unit of an electronic communications system that has linked our coast-to-coast supply network. This year it is scheduled to extend to overseas installations.

Heart of this system is the "transceiver," a desk-size transmitting and receiving device developed by International Business Machines Corp. Electronic impulses from coded card impressions are transmitted hundreds or thousands of miles to another transceiver, which punches an identical card at the receiving end. Within the United States, transceivers will be connected by leased telephone lines. Overseas installations will have radio connections. A cut of from 10 to 20 per cent in pipeline time was expected by the end of 1955, when the whole Zone of Interior network was in operation. Installation of overseas transceivers will effect another 10 per cent cut, at a conservative estimate. The resultant savings in inventory investment alone through more accurate and responsive requisitioning will be a very high multiple of the half million dollars a year which the system is costing us on a lease basis. In communications there remains no shadow of a doubt that automation will pay its way handsomely.

Inventory Control

Inventory control is always the potential quagmire of a logistical system. It is the area in which paperwork sprouts like a fungus, and constant re-evaluation is essential to ensure that the cost of control does not outweigh inventory value itself. The continually shifting, multibillion dollar global inventories of the Air Force pose an almost unique problem in this respect. We cannot safely trim provisioning to the most economical minimums unless our stocks are completely and immediately at our command at all times. Yet by present manual or punched card methods the paperwork essential to keeping track of our inventories in itself so impedes and slows the requisition cycle that it tends to accumulate excess inventories as a necessary margin of safety. Also, the more ponderous the machinery of control becomes, the less accurate and timely is its reflection of the data which influence management decisions concerning requirements, distribution, transportation, packaging, and handling. It is a vicious circle, from which we believe the data processing systems may help to extricate us.

One of the first of our applications of automation to the inventory-control problem, Underwood's ELECOM 125, a general purpose electronic computing system, was installed at Mallory Air Force Depot in Memphis, Tenn., world-wide supply center for antifriction bearings and a number of other property classes.

ELECOM is an experiment in an integrated and consolidated control system, a kind of master switch in which the various threads of inventory control are drawn together into an automatically functioning nerve center. The whole paperwork cycle of filling a requisition from depot stocks can be accomplished in about one second. All filing is handled on magnetic tapes, at a tremendous saving in record storage space, always a major problem in the handling of mass data. Moreover all static data stay in the machine, and only the dynamic data come out as paperwork. As a large percentage of our present paperwork is made up of static data (no change from last report), the basic clerical workload is greatly re-

duced. One manufacturer has estimated that the incidence of error in this type of equipment is about once in five billion operations.

We expect the system in full operation to reduce domestic pipeline time of low value equipment in the supply classes to which it is applied from the present 45 days to 5 days. Coupled with air transport for high value materiel, it can cut pipeline time within the Zone of Interior to a single day. The overseas pipeline will show comparable shrinkage.

A computer of generally similar capabilities, the IBM 702, has also been installed at our large depot in Oklahoma City. We anticipate eventual electronic systems at all our fifteen major depots. These first installations are, of course, research pilot projects intended to parallel and "look over the shoulder" of the current supply systems until the reliability of the equipment has been proved and our people have learned to apply it with full effectiveness.

Materials Handling

Carrying true electronic automation through from the paper-processing phases of supply to materials handling functions still remains a major problem for the future. The big computers can sort, memorize, and act upon data, but they are lacking in the physical senses which perceive the differing properties of matter. One of their most ardent proponents has admitted, for instance, that they will probably never be able to pick cotton.

However, we have been able to accomplish a great deal on the level of mechanical automation—with some electronic "boosters"—in the materials handling field. Many of our major depots now have—and all will eventually have—specially designed conveyor systems which channel material automatically from the commercial carrier through the various procedures of receipt, vouchering, sorting, inspection, processing for storage, and delivery to the storage area. The same system provides for movement of material being issued from stock, through packing, banding, marking, and weighing and, finally, to shipping.

Layouts include all types of powered and nonpowered conveyors, including chain conveyor systems with which a series of wheeled trucks can be hooked onto a moving sunken chain, unhooked at destination, and rolled to the storage shelves on processing units without further intermediate handling.

At many points along the closed circuit of the conveyors, machines add speed and accuracy to the operation. Electronically timed units to push off materials into predetermined receiving bays speed the initial sorting job. An automatic box-lid-removing saw drastically cuts uncrating time and preserves for repeated reuse costly containers which formerly were salvaged only as used lumber. Automatic canning machines in the unit-pack areas provide rapid protective packaging, especially vital for delicate electronic parts and instruments subject to shock damage and corrosion. We are now investigating an electronic method of photographically transferring shipping ticket details to shipping containers, aimed at greatly increasing accuracy and reducing the time required for such identification markings.

The conveyor system at our Ogden Air Materiel Area Depot, one of the first installed, has now been in operation more than two years. Our records—based on a comparison of actual man-hour costs per ton of materiel handled during the last year of the old system and the first year of the new one—are ample proof of the results which can be attained through even this necessarily limited approach to automation. Man-hours per ton dropped from 1.93 to 1.49. Total savings for the first year of operation in shipping and receiving, processing, inspection, research, and packing were $1,003,916. Savings in the first nine months completely amortized the cost of installation. By normal industrial standards such an investment would have been a sound one if the system could be amortized within the first two to ten years of operation. But automation has quickened both the pace

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Manufacturing Methods

In the fifth and final area of automation, manufacturing methods, we are, in a sense, silent but very active and vitally interested partners. We manufacture none of our own equipment, but it is of crucial importance to us that industry be able to produce superior weapons in sufficient quantity for our needs at prices within our budget limitations. Where such a great bulk of highly specialized equipment as we require is concerned, this is never a simple matter of off-the-shelf procurement. We must help to create the necessary industrial capacity by lending assistance with facilities, financial backing, materials, machine tools, and advance industrial planning which will help to ensure industry's ability to deliver the goods. The investigation and sponsorship of promising new manufacturing methods is one aspect of this responsibility.

It was inevitable that we should become interested in industrial automation in its earliest phases. Back in 1948 and 1949 we were studying and developing machine tool requirements for the heavy press program. In connection with this work we financed a contract for the design and construction of a numerically controlled milling machine. The Servomechanisms Laboratory at Massachusetts Institute of Technology designed the machine system and completed it in March of 1952. It was a pioneering step in industrial automation, since used experimentally in many applications.

Production machines now under development by the aircraft and machine tool industries, with controls based on derivations of the MIT system, should save a substantial amount of tooling dollars and considerably cut lead time on the manufacture of aircraft parts. It is estimated that on some parts they will eliminate as much as 85 per cent of the time now spent. Moreover they will open the way to rapid expansibility of production in the event of mobilization and provide a large degree of built-in quality control. The systems foreshadow a new era in aircraft production methods, a prospect of deep significance to air logistics.

Those are a few of our approaches to automation in five major areas where its impact is unmistakable and the advantages that it has to offer are already clearly evident, even in this embryonic stage.

Plans for the Future

At first we took automation as it came, developing it more or less independently in each area as the opportunity offered. However, automation is an absolute. A little of it is not effective. Applied in patchwork fashion, its power is diffused and dissipated. Complete systems must be automatized and synchronized if the whole tempo of output is to be accelerated. Obviously an isolated automatized machine or subsystem, dependent for input upon a long series of manual or nonautomatic operations, can do little to speed the en-

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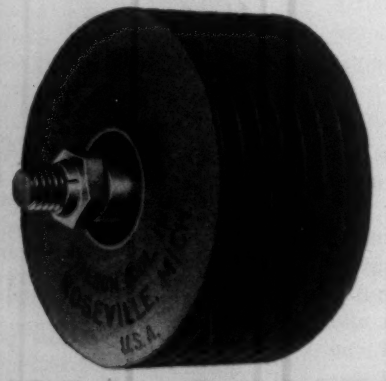

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tire cycle, which will be governed by its slowest common denominator.

We realized, therefore, that we would have to plan for integrated automation. Our first step has been a detailed outline plan for modernizing USAF logistics utilizing electronic data processing.

The study presents in considerable detail a three-to-five-year plan for automation in the Air Force logistical data flow system, what the system should be by 1960, and how the transition can be accomplished. It sets forth the organizational structures and procedures best adapted to optimum utilization of automatic systems and the steps toward achieving the goal, from acquiring the basic tools, through testing phases, to full scale operation of the new system. It analyzes progress to date and specific requirements in equipment, personnel, communications, and facilities; and it spotlights definite areas requiring further exhaustive study.

Finally it examines the dollar sense of the projected development program. Total cost would be approximately 42½ million dollars, a big figure until placed in perspective. In the calendar year 1954 alone, the Air Force disposed of some 575 million dollars worth of surplus material, much of it equipment which had become obsolete. Under existing systems this disposal could not be considered waste any more than hospitalization insurance is a waste in a year when illness does not strike. It represented the support necessary in our logistical system to make our airpower a sustained reality in war.

It is large, however, and since obsolescence will be with us as long as we are keeping abreast of advancing air science, we must of course keep surpluses to a minimum. The projected electronic data handling program, besides radically shortening pipelines, will greatly increase our precision in developing requirements for Air Force support. If it could effect just a 10 per cent saving in the initial capital investment in inventories—and this is a conservative expectation by present indications—it would more than compensate for the entire cost of the three-to-five-year program.

Optimistic as we are concerning the tremendous potentialities of automation in the new logistical equation, we have already become sharply aware of its problems. The ultimate use which we can make of it and the speed with which we can progress are limited, not by the machines themselves nor even by the inflexible restriction of available dollars. Manpower is the governing factor—and the human thought process.

The equation is clear before us today. Two tools are at hand—airlift and automation — which, combined, can give us the first truly flexible logistics for an air age. It remains for us now to prove that we can handle them.

From an article entitled, "A New Equation for Jet-Age Logistics" published in the Air University Quarterly Review, Spring 1955, *by the Air University, Maxwell Air Force Base, Ala.*

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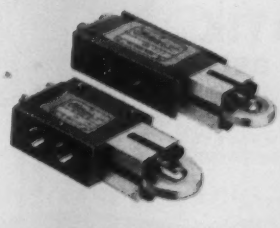

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Controls

CONTROL APPARATUS

Dual range control device consists of two sensing means responsive to separate but overlapping portions of the range of a variable, with associated individual controllers but a single variable regulator, and means rendering one of the controllers ineffective in accordance with values of the variable. Patent 2,723,682 by Richard G. Haney and George W. McKnight, assigned to Minneapolis-Honeywell Regulator Co.

COMBINED FLUID PRESSURE AND ELECTRICALLY CONTROLLED SERVOMOTOR SYSTEM

Servomotor control system integrates several control factors to determine ouput of an amplifier to the servomotor. Influence of various factors is effected through individual differential transformers. Patent 2,722,198 by William D. Macgeorge, assigned to Automatic Temperature Control Co. Inc.

♦ ♦ ♦

Handling

MAGNETIC CONVEYOR AND AGITATOR

Conveying and agitating means includes two parallel pairs of alternately magnetically energized rails and means for moving the rail pairs longitudinally and vertically with respect to each other. Patent 2,722,406 by Frank L. Kurek.

♦ ♦ ♦

Machines

ASSEMBLING MACHINE

Machine assembles unit consisting of a screw, brush holder, brush, and terminal clip carrying a lead wire. Workholders are conveyed to successive stations and pin means locate the parts. Patent 2,723,691 by James S. Burge, Hilton J. McKee, Loris H. Conrad, Warren M. Rider, and James F. Salatin, assigned to General Motors Corp.

COILING APPARATUS

Reel winding equipment for a rolling mill includes a belt wrapper assembly to assist in wrapping strip material around the reel and a bending roll to bend the end of the strip before it is wound so that it will be tightly wrapped around the coil. Patent 2,725,104 by Frank J. Wood, assigned to Kaiser Aluminum & Chemical Corp.

♦ ♦ ♦

Measuring

FLOW VELOCITY INDICATING DEVICES

Velocity of liquid flowing through a chamber is indicated by speed of rotation of a bladed rotor. Revolutions of the rotor are indicated by interruption of a light beam by a tab on the rotor. Patent 2,723,562 by William A. Lutz and John D. Maitland, assigned to Dorr-Oliver Inc.

APPARATUS FOR GAGING AND MARKING LENGTHS OF GLASS TUBING

Rotation of measuring rolls in contact with moving tubing causes mercury to rise in a column and complete circuits between sets of contacts. Patent 2,721,317 by Louis R. O'Neill, assigned to Westinghouse Electric Corp.

♦ ♦ ♦

Packaging

PACKAGE WRAPPING MACHINE

A rotating gripping device positions package and wrapper material so that sealing material may be applied and the wrapper cut to length. Patent 2,720,738 by Robert R. Brightwell, assigned to Stephano Brothers.

APPARATUS FOR HEAT SEALING

Heating element in heat sealing machine is disconnected at a preselected temperature. When element cools to a preselected lesser temperature the sealing pressure is automatically relieved. Patent 2,719,567 by Edward B. Gardner, assigned to Emhart Mfg. Co.

♦ ♦ ♦

Process Design

METHOD OF FABRICATING ELECTRODE SPACERS

Rigid insulating spacers having apertures therein are formed by continuously feeding a flexible glass tape between heated rolls having matched projections and depressions to form apertures and spaced transverse impressions. Heating and subsequent cooling are sufficient to make the tape rigid and individual spacers are broken off by striking the transverse impressions. Patent 2,724,216 by Luther E. Cisne, assigned to Bell Telephone Laboratories Inc.

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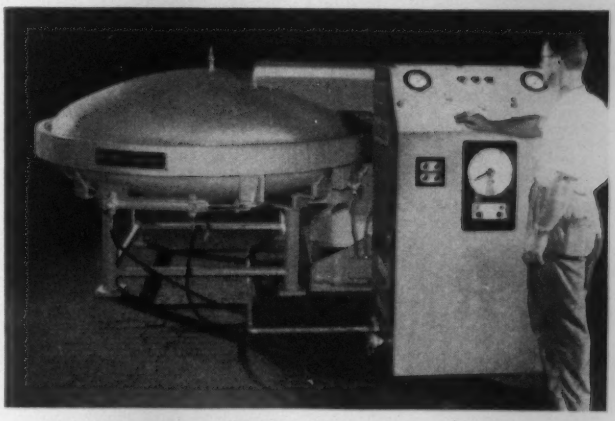

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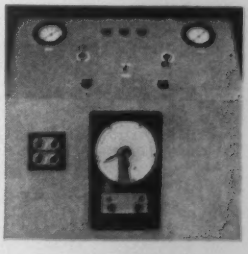

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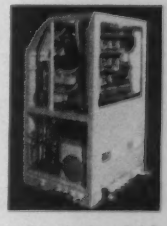

Interior of control panel with covers removed.

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CUMULATIVE EDITORIAL INDEX

Including six issues. Number preceding the hyphen is mon'h of issue; those following are page numbers in that issue.

A

Accounting, machines, 11-57
Administration, office, 9-140
Aerosols, 10-26
Air Force automation, 2-118
Air motors, 11-61
Aligning machine elements, 9-120
Aluminizing, 10-32
Amber, G. H.
Automatic Dull Drill Detection, 10-53
Amplifier, magnetic, 1-8
Analog computers, 12-95; 2-38
Analysis,
of atmosphere gas, 9-54
of control system, 9-57
Anderson, P. L.
Producing Circuits for Mechanized Electronics Assembly, 11-71
Aqueous solutions,
conductivity control, 10-49
Arithmetic, computef, 2-45
Assembly, 10-11; 11-42
Atmosphere, control, 9-54
Atomic power reactors, 2-130
Automatic control,
programming, 9-141
Automation,
aboard ship, 1-11
and business, 10-100; 1-128
and labor, 1-128
and management, 10-100
definition of, 11-35
design for, 11-34
economics, 11-35; 2-28
effects of, 1-128
grinder, 1-53
history, 9-130
in Britain, 11-113; 1-128
in foundry, 10-71
machine tool field, 9-40; 1-128
ordnance field, 11-62
philosophy, 9-130; 10-100
social effects, 1-128
Automotive parts manufactured, 11-77
bumpers, 2-42

B

Banking, 11-57; 1-70
Barrels, automatic cleaning, 12-44
Batteries, 2-10
Battery manufacture, 11-54
Beer, continuous processing, 9-123
Bergere, E. W.
Automatic Positioning, 9-52
Bessonny, A. I.
Continuous Registration, 11-54
Bill of material, 9-75
Binary,
code, 1-70
numbers, 2-45
Blanking of sheet metal, 1-34
Blasting, 9-71
Bleaching, 1-77
Blending, 12-26; 1-42
Boards, circuit, 11-71
Bolz, R. W.
Design for Automation, 11-34
Progress and Obsolescence, edit, 2-27
Boring, gear plates, 9-69
Bottle cap manufacture, 11-54
Boxing, 9-71
Brewing, 9-123
British automation, 11-113
Brooks, R. W.
How Numerical Control Works, 2-45
Brown, J. J.
A Caveat on Computers, 2-38
Buffers, 2-45
Bumpers, plating, 2-42
Bundling, 11-66
Business and automation, 10-100
Business forecast, 2-10
Business systems, 12-54

C

Calculator component manufacture, 11-36
Calenders, 12-51
Calender control, 9-34
Camera's, 2-7
Can filling, 2-63
Canning, 2-42
Carbide tools, 9-72
Carbon dioxide,
manufacture, 1-38
measurement, 9-54
Cards, punched, 10-36, 94; 11-57; 1-70; 2-7
Carton opening and sealing, 12-101
Casting, continuous strip, 11-101
Cell type plating, 11-77
Check processing, 11-57
Chemi-groundwood process, 2-58
Chemical engineering cost estimation, 11-120
Chemical handling, 2-58
Chrome plating, 2-42
Circuits, 11-71
electrical, 1-48
Cleaning, 9-71
barrels, 12-44
Clerical procedures, 11-57
Close, G. C.
Producing Steel Drums, 1-62
Closed-loop, frequency response, 9-57
Coatings, control, 9-34
Code, binary, 1-70; 2-45
Coding, 1-70
Coil stock processing, 1-34
Coiling, 2-127
Colgan, W. J.
Automation in Ordnance, 11-62
Communications, 10-17, 45; 2-118
Computation, potentiometer, 2-52
Computers, 2-38, 45
analog, 12-92
digital, 9-41; 11-57
Conductivity control, 10-49
Conduit bundling, 11-66
Contents, 2-3
Continuous casting, 9-118
Continuous heat treating, 1-49
Continuous processing, 1-38
Continuous strip processing, 12-37
Control,
acidic condition, 1-10
apparatus, 12-100
boards, 12-70
business system, 12-54
casting, 10-94
computer, 2-38
conductivity, 10-49
conductivity difference, 12-63
continuous heat treating, 1-49
conveyor, 12-100; 1-60
crane, 9-118
design, 10-40
differential transformer, 9-65
doors, 10-17
dull drill detection, 10-53
electrical, 10-104; 1-116; 2-72
electrical trouble shooting, 1-48
electronic, 11-54; 12-52; 2-67
electropneumatic, 2-130
extrusion press, 10-17
feedback systems, 2-130
fluoride concentration, 12-63
foundry, 10-71
hydraulic, 10-104
machine tools, 9-118; 10-36, 104; 11-10; 12-65, 92, 101
maintenance of, 10-40
malting, 10-66
moisture, 9-118
motor, 10-94
numerical, 2-45
panels, 12-70; 1-38
plating, 10-49
pneumatic, 2-67
potentiometer, 2-52
pressure, 2-58
process, 9-57; 12-70; 2-67
process variables, 11-120
program, 11-120
punched cards, 10-36
registration, 12-52
remote, 1-110
rinse water, 12-63
servomotor, 2-126
sheet register, 11-54
speed, 11-54
stream pollution, 12-63
system analysis, 9-57
tape, 9-52, 69; 11-10
temperature, 1-77; 2-58
traffic, 9-20
tuning, 9-23
Converters, 2-52
Conveying, 10-26, 32; 1-60; 2-42
Conveyors,
army field, 11-13
belt, 9-123
coal, 1-60
dispatch system, 11-100
heat treating, 1-49
in cell type plating, 11-77
magnetic, 2-126
pneumatic, 9-123
screw, 9-123
V-belt, 2-42
Conveyor scales,
continuously totalizing, 12-26
intermittent, 12-26
Copper plating, 2-42
Cost,
control, 2-28
manufacturing, 11-35
Cost estimation, chemical engineering, 11-120
Counter controller, 1-8
Culp, L. D.
Wire Mill Cuts Decarb, 9-54
Curing, 11-44
Cutoff machine, 10-95
Cutting envelopes, 10-46
Cutting tools, 2-12
Cylinder,
explosive actuated, 9-18
pneumatic, 11-61

D

Data processing, 9-22, 75; 10-94; 11-57, 12-10, 54, 104; 1-13, 70, 110; 2-7, 118
Data recording, 10-10
Deburring, 9-71; 10-69
Decimal,
counting unit, 1-8
keyboard, 11-20
numbers, 2-45
Deoiling, 9-71
Design, 11-34; 12-104
die, 11-120
hydraulic, 1-128
materials for, 1-128
pneumatic, 1-128
Detergent manufacture, 2-63
Die-blanking, 11-71
Die casting, 12-97
Die design, 11-120
Differential,
transformer, 9-65
transmission, 11-54
Digital computers, 11-57; 2-38
Diode, silicon power, 10-15
Distribution: See Warehousing
Distributors, 9-140
Downtime, 10-53
Drilling, 9-52; 10-69
dull detection of, 10-53
Drives, V-belt, 2-130
Drums, automatic cleaning, 12-44
Dry ice manufacture, 1-38
Drying ovens, drum manufacture, 1-62
Dull drill detection, 10-53
Duncan, R. A.
Electronics in Process Control, 2-67

E

Economics, 1-122; 2-28
Electrical,
control, 10-104; 1-116; 2-72
standards, 2-9
trouble shooting, 1-48
Electromagnetic switch, 11-108
Electromechanical switch, 11-112
Electron tube switch, 11-111
Electronics,
computers, 2-38
control, 2-67
distributors, 9-140
graph paper, 1-67
manufacture of, 9-141; 11-71
Electroplating, continuous, 12-37
Electrostatic photography, 2-9
Electrostatic spraying, 10-15
Elevators, parts, 1-53
Embossed data plates, 1-70
Employment, 9-39
Envelope manufacture, 11-54
Eppert, R. R.
Automation is an Asset in Banking, 11-57
Escapement, 2-9
Estimation, 11-120
Explosive actuated cylinder, 9-18
Extruding aluminum, 10-17

F

Fabricating, glass insulators, 2-127
Farming, 9-33
Farr, C. P.
Transfer Machine Aims for Flexibility, 1-58
Fastener, hub to shaft, 11-20
Feedback,
business system, 12-54
control systems, 2-130
Feeders, 2-9
constant weight, 1-42
hopper, 1-53
loss-in-weight, 1-46
V-belt, 2-42
weight control, 1-42
Feeding, 10-69; 2-72
alum solution, 1-10
logs, 9-24
sheet metal, 1-34
small parts, 1-53
vibratory, 11-67
Filling, 2-63
Finishing, plating, 2-42
Fixtures, 1-58
Fluid sealing, 11-75
Food processing, 9-33
Forecast of Business, 2-10
Foundry, automation, 10-71
Frequency response, 9-57
Fuel tanks, 2-8
Furnaces, 1-49
wire mill, 9-54
vacuum, 2-9

G

Gaging, 2-44
air, 10-95
radiation, 9-34
sheet thickness, 11-101
Garrott, P. B.
New Coding Systems Broaden Data Processing, 1-70
Produce Your Paperwork Automatically, 9-75
Gas furnace, heat treating, 1-49
Gassett, G. W.
Newsprint from Hardwoods, 2-58
Gates, 2-45
Germanium transistors, 11-48
Gluck, S. E.
Weight Control of Bulk Materials, 12-26; 1-42
Grain, bulk handling, 9-123
Graphic panels, 12-70
Graphic presentation, 1-67
Gray, H. L., Jr.
Use Resistance Potentiometers, 2-52
Grinding, 1-53; 2-42

H

Handling, 9-118; 10-94; 11-100; 1-110
bulk, 9-123; 12-26; 1-42
cigarettes, 12-34
coil stock, 1-34
conveying, 2-42
feeding, 10-69; 11-67; 12-101
liquids, 10-26
loading, 11-44
pneumatic, 9-123
small parts, 1-53
television tubes, 10-32
unloading, 11-44
Hansford, V. N.
Projectiles Welded Automatically, 2-72
Harry, D. W.
Modern Product—Aerosols, Modern Production—Automation, 10-26
Heating, induction, 10-64
Heat treating, 1-49
Host, J. A.
Automatic Assembly, 11-67
Hydraulics, 9-139; 12-44; 1-128; 2-58
components, 12-100
control, 10-104
equipment design, 9-140
machine tools, 1-116
special hose, 1-11

I

Impregnating, 11-44
Impulse,
contactor, 12-13
generator, 1-18
Induction heating, 10-64
Infrared,
analysis, 9-54
bibliography, 10-109
Inspection, 2-44
X-ray, 2-63
Instruments, 1-122; 2-58
control, 12-70, 104; 2-67
measurement, 12-104
Integrated data processing, 1-70
Inventory,
automatic system, 1-13
control, 2-118
Irwin, C. B., Jr.
Transistors in Automation, 11-48

J

J-boxes, 1-77

K

Kendall, G. H.
Automatic Assembly, 11-67
Keyboard, x-y plotter, 11-15
Kier method, 1-77
Kits, prototype development, 9-20
Kniveton, J.
Short-Cycle Heat Treatment, 1-49

L

Labor, cost, 9-33
Laplace transforms, 2-130
Leaver, E. W.
A Caveat on Computers, 2-38

Leveling, coil stock, 1-34
Liquid meters, recording, 12-13
Liquid level, measuring, 11-101; 1-110
Lithography, drum manufacture, 1-62
Loader, mechanical, 10-95
Loading, 2-72
  ammunition, 11-62
Logic functions, 2-45
Logistics, 2-118
Lyden, J. F.
  Automation Applied To Sheet Metal Blanking, 1-34

M

Machine programming, punched card, 10-36
Machine tools, 9-40, 130
  control, 9-120; 10-104; 12-92
  control by punched cards; 10-36
  cycling, 1-111
  design, 10-104; 1-58, 116
  drilling, 12-62
  drilling and deburring, 10-69
  drill, dull detection, 10-53
  economics, 9-39
  electrical controls, 1-116
  hydraulics, 1-116
  programming, 10-36
  punched card control, 10-36
  punch press, 10-36
  transfer, 12-62; 1-58
  trends in design, 9-40
Machines,
  accounting, 11-57
  assembly, 9-120; 10-12; 2-126
  boring, 9-69
  character recognition, 1-70
  hydraulic, 9-139
  mining, 9-120
  testing, 9-120; 2-14
  welding, 2-72
Machining, 11-42
  tolerances, 11-39
Magnetic amplifier, 10-108; 1-8
  drums, 1-110
Magnetic materials, 12-104
Magneto manufacture, 11-61
Magnets, 2-44
Maintenance, 12-97; 1-48; 2-28
  plant, 9-139
Malt, bulk handling, 9-123
Malting process, 10-66
Management, 10-100
  controls and techniques, 1-128
Manufacture of,
  aerosols, 10-26
  Air Force materiel, 2-118
  automobile bumpers, 11-77; 2-42
  batteries, 11-54
  bottle caps, 11-54
  calculator components, 11-36
  carbon dioxide, 1-38
  cloth, 1-77
  detergent, 2-63
  drums, 1-62
  dry ice, 1-38
  envelopes, 11-54
  extrusions, 10-64
  fuel tanks, 2-8
  gasoline, 2-67
  generator shafts, 11-37
  kilns, 10-14
  magnetos, 11-61
  magnets, 2-44
  paper, 9-34; 2-58
  pipe, 1-49
  pistons, 11-34
  printed circuits, 11-71; 1-111
  projectiles, 2-72
  razor blade envelopes, 10-46
  rubber, 9-34
  siding boards, 11-54
  steel drums, 1-62
  television tubes, 10-32
  tire fabric, 12-51
  transformers, 11-44
  tubes, 11-41
  typewriters, 12-62
Manufacturing engineering, 1-120
Marking, 12-101
Materials, 1-128
  handling, 2-14, 118
  packaging, 10-109
  research, 9-141
Mathematics, 9-139; 1-128
Measuring, 11-41, 101; 2-127
  can filling, 2-63
  clearance rotating shaft, 11-20
  concentration, 9-54
  conductivity, 9-120
  differential transformer, 9-65
  electronic instruments, 10-108
  humidity, 9-121
  movement, 12-65
  pressure, 9-121
  temperature, 9-118
  thickness, 9-34
Mendleson, I.
  Detergent Production Line, 2-63
Metallizing, vacuum, 10-32
Metal-plastic combination, 10-13
Metalworking survey, 2-8
Mohler, J. B.
  Conductivity Control, 10-49
  Continuous Processing of Steel Strip, 12-37
Molding, automated, 10-71
Money order processing, 11-57
Motor,
  air, 11-61
  variable speed ac, 10-11
Murphy, E. G.
  Industrial Measuring and Control, 9-65

N

Newsprint, 2-58
Nickel plating, 2-42
Normalizing, pipe production, 1-49
Numbers, 2-45
Numerical control, 2-45

O

Office automation, 1-128
Oiling strip, 10-95
Open loop frequency response, 9-57
Operations research, 2-130
Optical gratings, 12-65
Ordnance, 2-72
  loading techniques, 11-62
Orientation, 11-57, 100; 1-110
O-ring sealing, 11-75
Oscilloscope, self-compensating, 1-67
Ovens, 11-44

P

Packaging, 9-71; 10-26; 11-101; 12-34; 1-110; 2-10, 63, 127
  materials, 10-109
Pallet carriers, 11-44
Pallets, machine tool, 12-62
Panels, circuit test, 1-48
Papermaking, 2-58
Paperwork, mechanized, 9-75
Patents, 2-10
Perkowski, N.
  Developing a Maintenance Program, 2-28
Philbrick, G. A.
  System Analysis Improved, 1-67
Philosophy, 11-113
Photo processing, 10-13
Photography, 2-7
  electrostatic, 2-9
Photoelectric scanners, 12-52
Pipe,
  bundling, 11-66
  heat treating, 1-49
Piston manufacture, 11-34
Plant layout, 9-139
Plant maintenance, 9-139
Plastic-metal combination, 10-13
Plastics, spraying, 10-15
Plates, embossed data, 1-70
Plating, 2-42
  chromium, 11-77
  continuous strip, 12-37
  control, 10-49
  copper, 11-77
  nickel, 11-77
  tin, 12-37
Pneumatic,
  control, 2-67
  controllers, 2-58
  conveying, 9-123
  cylinders, 11-61
  power, 1-128
  tube communications, 10-45
Polishing, 12-69
Positioning, 9-52, 69; 12-65, 101
Potentiometers, 2-52
Potteries, 9-72
Powder presses, 11-62
Presses, 1-38
  blanking, 1-34
  punch, 9-71
  tape programmed, 9-17
Preventive maintenance, 12-97
Printed circuits, 9-141; 11-71; 12-101; 1-111
Printing, 10-46; 11-54; 12-52
Process control, 11-120; 2-67
  continuous webs, 9-34
  malting, 10-66
  pulp making, 2-58
Process design, 9-121
Processes of production, 11-34
Processing of,
  coil stock, 1-34
  strip stock, 1-34
Product design, 11-34; 1-120
Production,
  mass and flow, 11-120
  orders, 9-75
  techniques, 1-120
Program control of process variables, 11-120
Programming,
  punched card, 10-36
  remote operations, 10-14
Projectile, manufacture, 2-72
Proportioning, 12-26
Protection, overload, 12-26
Proximity, impulse generator, 1-18
Punch press, 9-71
Punched cards, 11-57; 1-70; 2-7
  machine tool control, 10-36
Punched tape, 9-69, 75; 11-57; 1-70 2-7

R

Radiation gaging, 9-34
Ranges, bleaching, 1-77
Rawlings, E. W.
  Automation . . . Key to Air Force Logistics, 2-118
Reader, automatic, 11-59
Receiving tube, ceramic, 12-9
Recording,
  data, 9-118; 10-10
  flow, 10-16
  sound, 9-118
Rectifiers, 10-15
Refinery, 2-67
Reforming, 2-67
Register, 11-54
Relays,
  coilless, 2-8
  design of, 12-104
  overvoltage, 1-16
Resistance potentiometers, 2-52
Response, control system, 9-57
Retail tags, handling, 12-10
Retarders, automatic, 12-11
Reusable containers, cleaning, 12-44
Riveting, 9-52
Rolling mill control, 9-34
Rolling, stainless steel, 11-101
Rosenthal, R.
  Conductivity Control, 10-49

S

Safety,
  devices, 12-52
  standards, 11-120
Schneider, D. B.
  Punched Card for Machine Tool Control, 10-36
Schroeder, C. J.
  Automatic Barrel Cleaning, 12-44
Sealing, 10-95
  static, 11-75
Servosystems, 12-92
Set screw orienting, 11-6
Shaft manufacture, 11-37
Shaping pottery, 9-72
Shearing, coil stock, 1-34
Sheet metal blanks, 1-34
Sheeting, 11-54
Shell molding, 12-101
Shipping labels, 9-77
Short-cycle heat treating, 1-49
Shot blasting, 9-71
Siding board manufacture, 11-54
Silicon transistors, 11-48
Sisson, R. L.
  Business Systems Can Be Engineered, 12-54
Solutions, conductivity control of, 10-49
Sound,
  absorbers, 1-18
  analyzers, 12-12
  recorders, 12-12
Speed control, 11-54
Spraying, electrostatic, 10-15
Stainless steels, fabrication of, 1-128
Stamping, 9-71
Standards,
  electrical, 2-9
  safety, 11-120
Static sealing, 11-75
Steel strip processing, 12-37
Stevenson, R.
  Parts Handling—Key to Grinder Automation, 1-53
Storage, 11-67
  bulk materials, 12-101
Strip stock processing, 1-34
Surface finish tolerances, 11-39
Survey, metalworking, 2-8
Switches, 1-110
  centrifugal, 11-100
  delayed action, 1-110
  stepping, 10-69
Switching, 11-108
  pneumatic tube, 10-45
Systems,
  analysis, 1-67
  automatic, 11-38
  business, 12-54
  communication, 10-45
  control, 10-108; 12-92; 2-130
  conveyor dispatch, 11-100
  data coding, 1-70
  maintenance, 12-97

T

Tapes,
  common language, 9-75
  control, 9-17, 52, 69; 11-10
  error reader, 1-10
  punched, 9-69, 75; 11-57; 1-70; 2-7
  wrapping, 11-66
Television, iris adjustment, 12-11
Television tubes, manufacture of, 10-32
Temperature, 2-58
Tension control, 12-37
Terminology, 10-109
Testing, 10-95; 2-44
  machines, 2-14
  tables and data, 11-120
  ultrasonic, plate, 1-16
Thermistors, 2-130
Thickness gage, 11-101
Thread roller, 12-15
Thyratron, 11-54
Tolerances, 11-39
Tooling, 9-72
Toolmaking, 9-140
Tools, cutting, 2-12
Traffic control, 9-20
Transfer machines, 12-62
  flexibility, 1-58
Transformer,
  differential, 9-65
  manufacture, 11-44
Transient response, 9-63
Transistors, 9-139; 11-48
  switch, 11-109
  use of, 10-109
Travelers checks, 1-70
Trouble shooting, electrical, 1-48
Tube manufacture, 11-41
Tubes, ceramic receiving, 12-9
Tubing bundling, 11-66
Turning, polygon shapes, 9-17

U

Ultrasonic, 2-51
  testing, 1-16
Unpacking, 10-26
Unscrambler, 2-63
  logs, 9-24

V

Vacuum,
  forming of plastic, 2-10
  furnaces, 2-9
  metallizing, 10-32
Variable speed drive, 11-54
Varistors, 2-130
Varnishing, 11-44
V. belt conveyors, 2-42
Ventilation, 9-139
Vibration monitors, 12-10

W

Walter, L.
  Graphic Panels Expedite Control, 12-70
Walters, N. E.
  Controlling Continuous Web Processes, 9-34
Warehousing, 9-33
Washing,
  coil stock, 1-34
  reusable containers, 12-44
Web,
  register control, 11-54
  thickness control, 9-34
Weftless creel process, 12-51
Weighing, 11-101
  bulk materials, 12-26; 1-42
  liquids, 10-26; 2-63
Weight-control feeders, 1-42
Welding, 2-72
  kilns, 10-14
Williamson, D. T. N.
  Light Helps Control Machining Operations, 12-65
Worley, C. W.
  Basic Process Control, 9-57; 10-40

X

X-ray inspection, 2-63

Z

Zagusta, J. A.
  Producing Circuits for Mechanized Electronics Assembly, 11-71